INTEGRATED EDITION OF THE PETROLEUM ENGINEER

the Petroleum Engineer

FOR MANAGEMENT

MAY 1959

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ONE DOLLAR FIFTY CENTS A COPY

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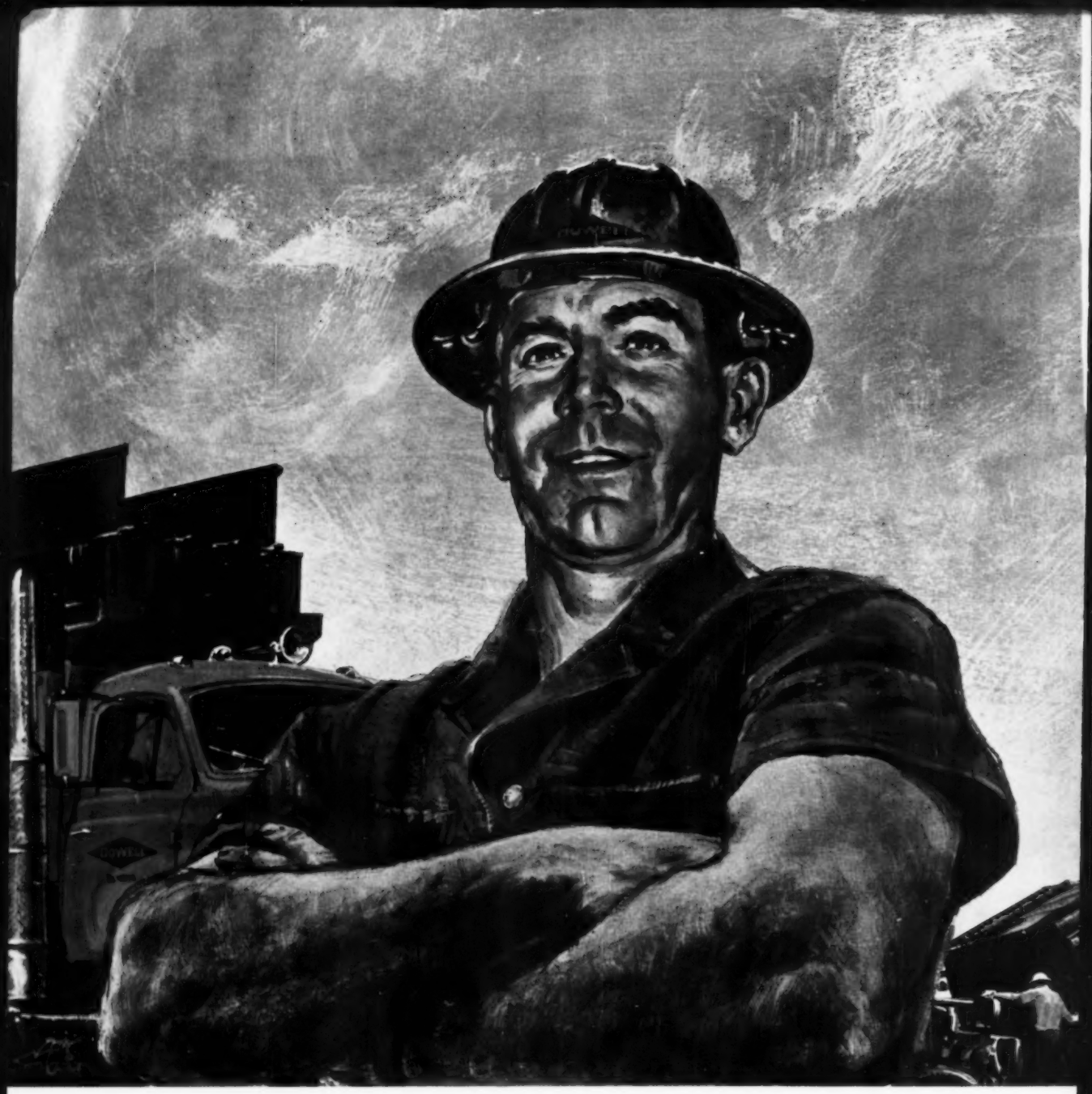


MORE POWER PER POUND with Dowell equipment. When you specify Dowell for your acidizing or fracturing treatments you get more power, pound-for-pound, than you do from any other service company. Dowell designs its pumping, mixing and blending equipment to save you money. Headed by the compact, powerful Allison aircraft-engine pumper, Dowell's equipment is streamlined to keep your costs as low as possible—consistent with the power you need for your well treatment. If your job calls for small volumes, minimum power, you don't have to pay for a lease-full of equipment. And when the job calls for big power, you get it without unnecessary bulk or weight from Dowell. This variety of versatile, specialized equipment is one more reason why Dowell offers you most value per treatment dollar. Dowell, Tulsa 1, Oklahoma.

Services for the oil industry

DOWELL

DIVISION OF THE DOW CHEMICAL COMPANY

The Petroleum Engineer Publishing Company's

OIL SHOW PICTORIAL

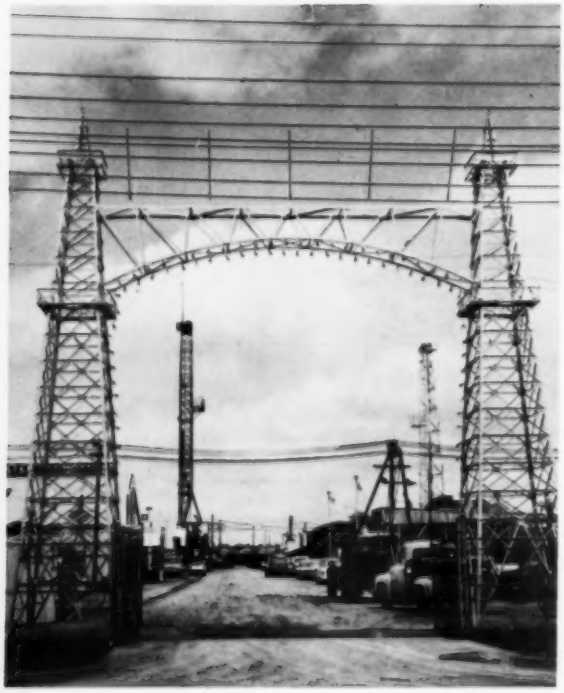
The 14th International Petroleum Exposition to be held in Tulsa, Oklahoma May 14-23 this year reaches a new all-time high in industrial shows . . . and supersedes any oil show in the past. Since 1923 . . . year of the first Tulsa oil show . . . the petroleum industry has made astonishing strides in technology. To those who have experienced former oil shows, this progress becomes obvious in viewing the maze of equipment, services and products now offered the industry.

To oil people everywhere who have not experienced an International Petroleum Exposition, the 1959 Oil Show will indeed be a thrilling experience. Very seldom in the life time of any oil man does he have the opportunity of viewing at one concentrated site all the progress in his industry wrapped up in one convenient, attractive package. This month, he will get such a chance.

Assembled on 30 acres in the east side of Tulsa is some $500 million worth of oil industry equipment by over 650 exhibiting companies. It is without a doubt the greatest concentration of modern petroleum machinery ever to be found anywhere, anytime. No detail has been overlooked to make this the most informative, interesting and constructive petroleum equipment show ever presented.

The editors of The Petroleum Engineer Publishing Company and its four specialized petroleum publications, have assembled a galaxy of photographs of what you'll see when you visit the Tulsa Oil Show this month. While there is still some last minute painting and polishing, the following pages give you a quick review of IPE . . . a memento of the show for those planning to attend . . . the second-best tour for those who are unable to go.

TEXAS

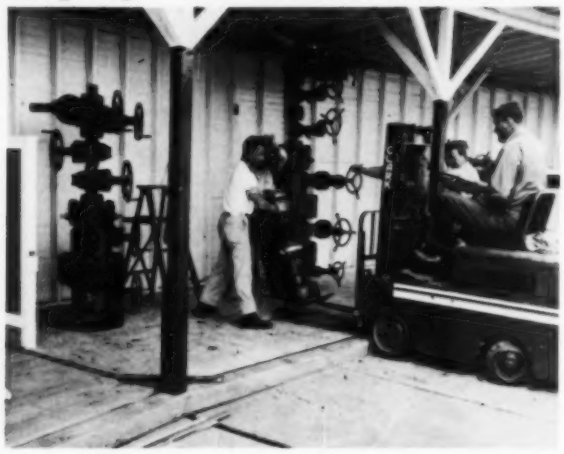


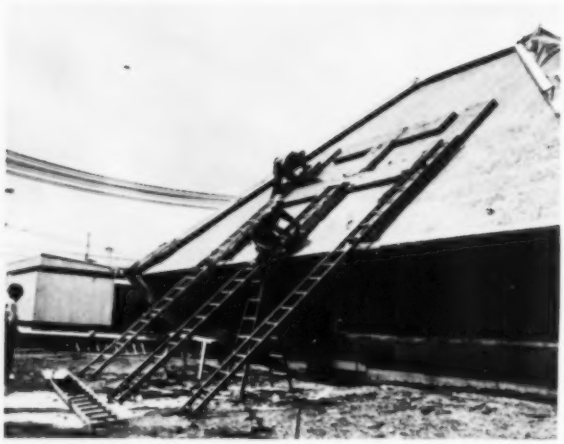
INTERNATIONAL PETROLEUM
EXPOSITION
May 14 - 23, 1959

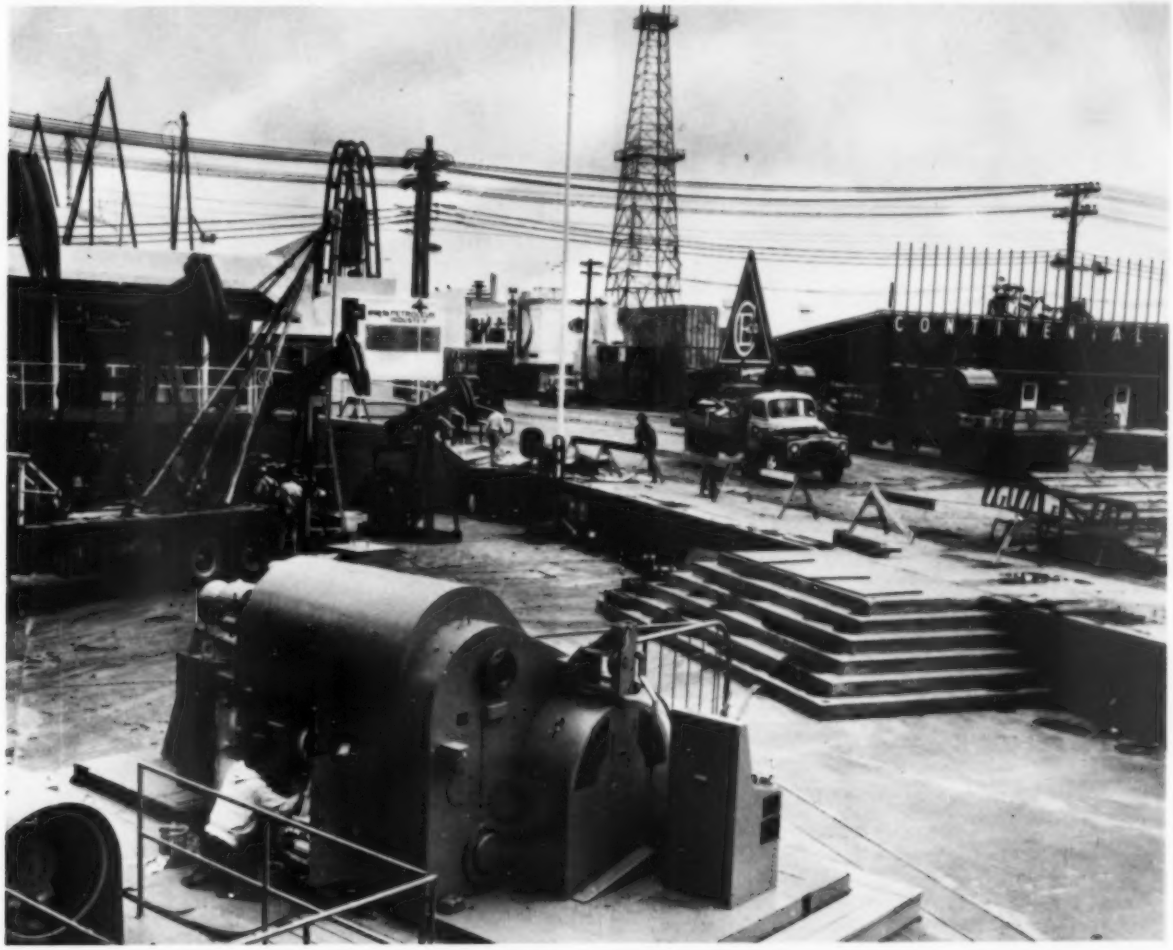
OKLAHOMA

LUFKIN
THE PETROLEUM
Engineer

SKELLY DR.



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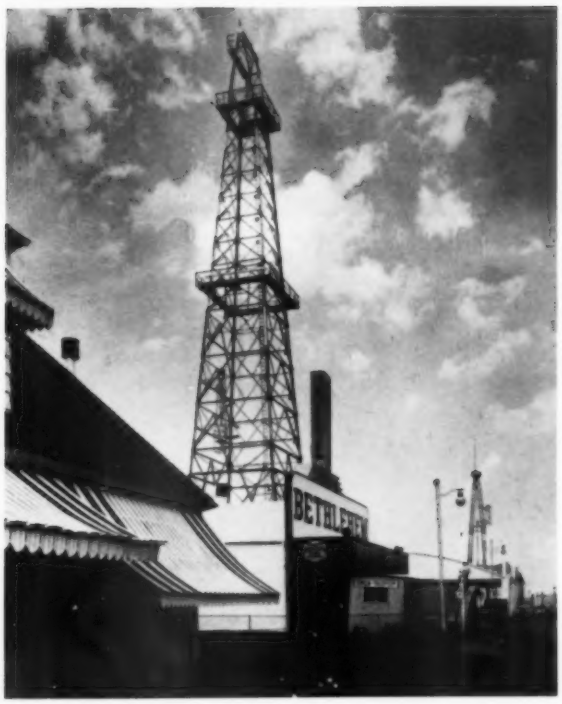
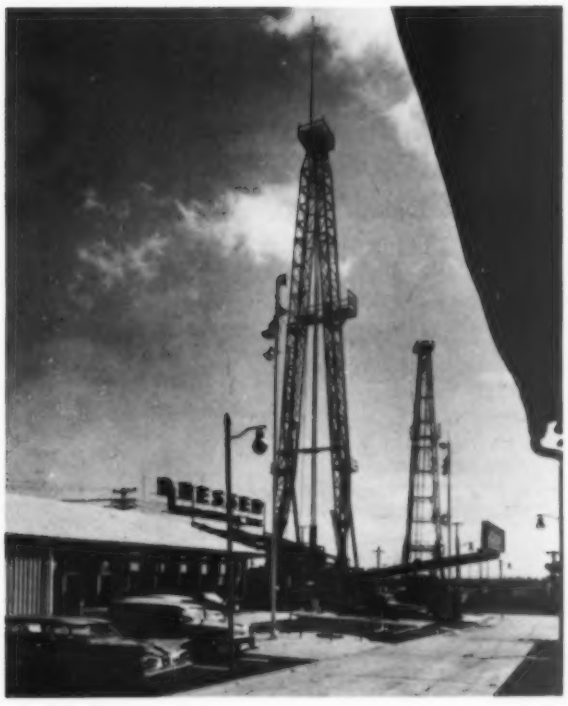
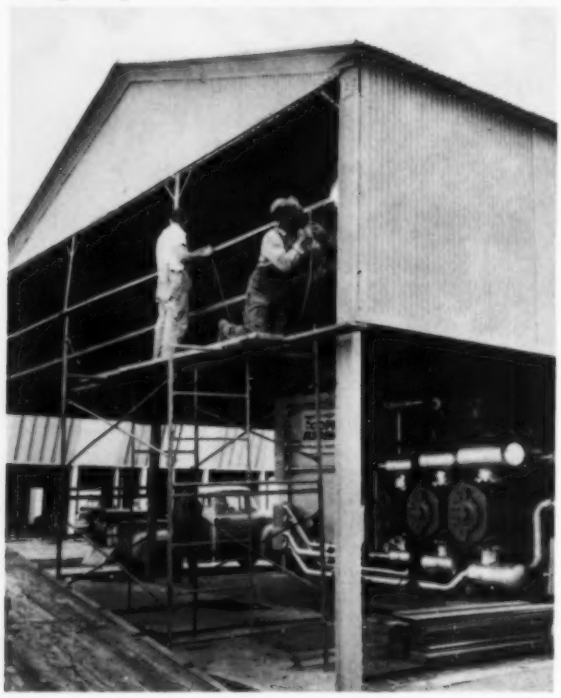
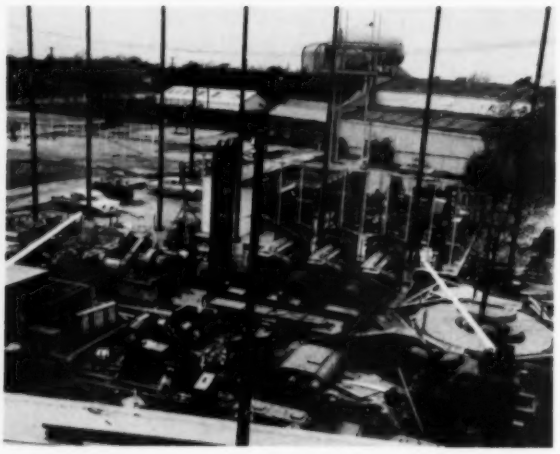

BETHLEHEM


DRESSER

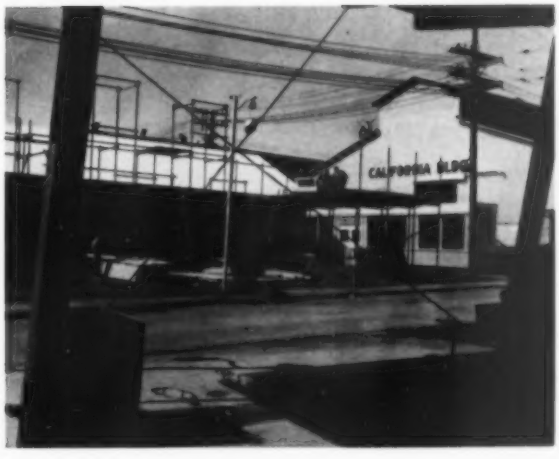
BETHLEHEM
TEXAS





BETHLEHEM
SUPPLY

CO.



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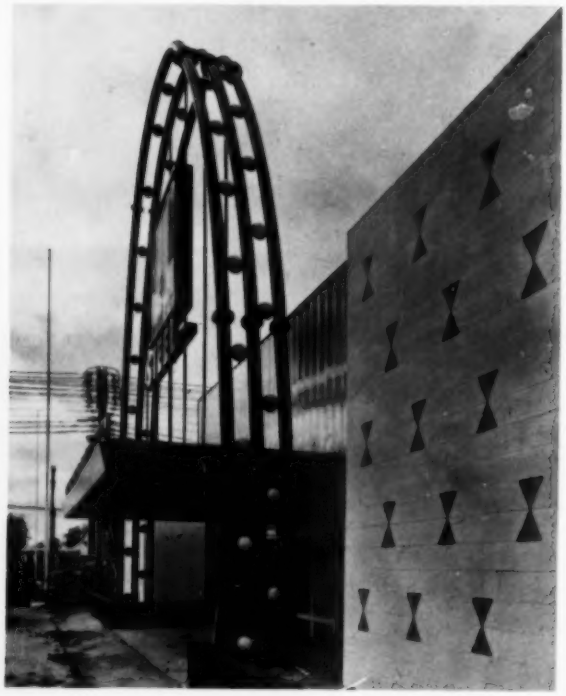
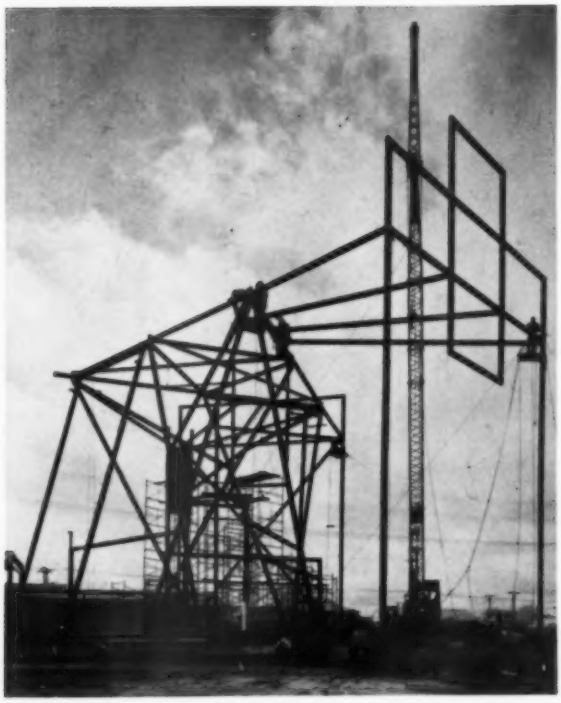
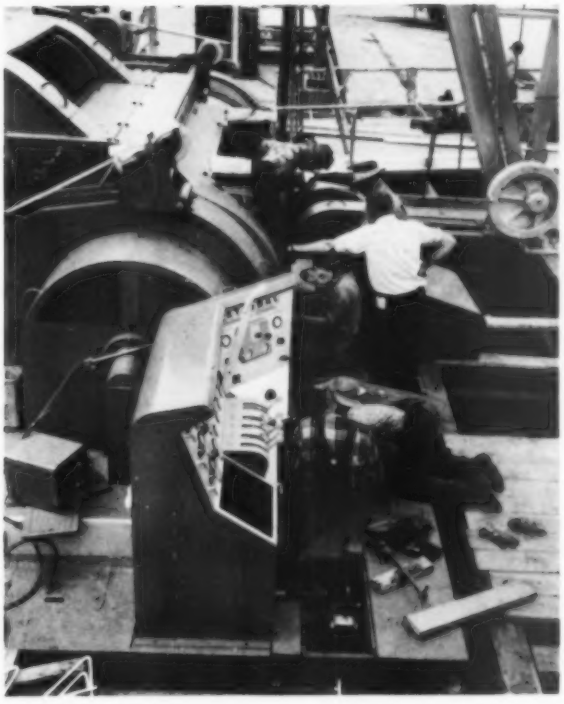
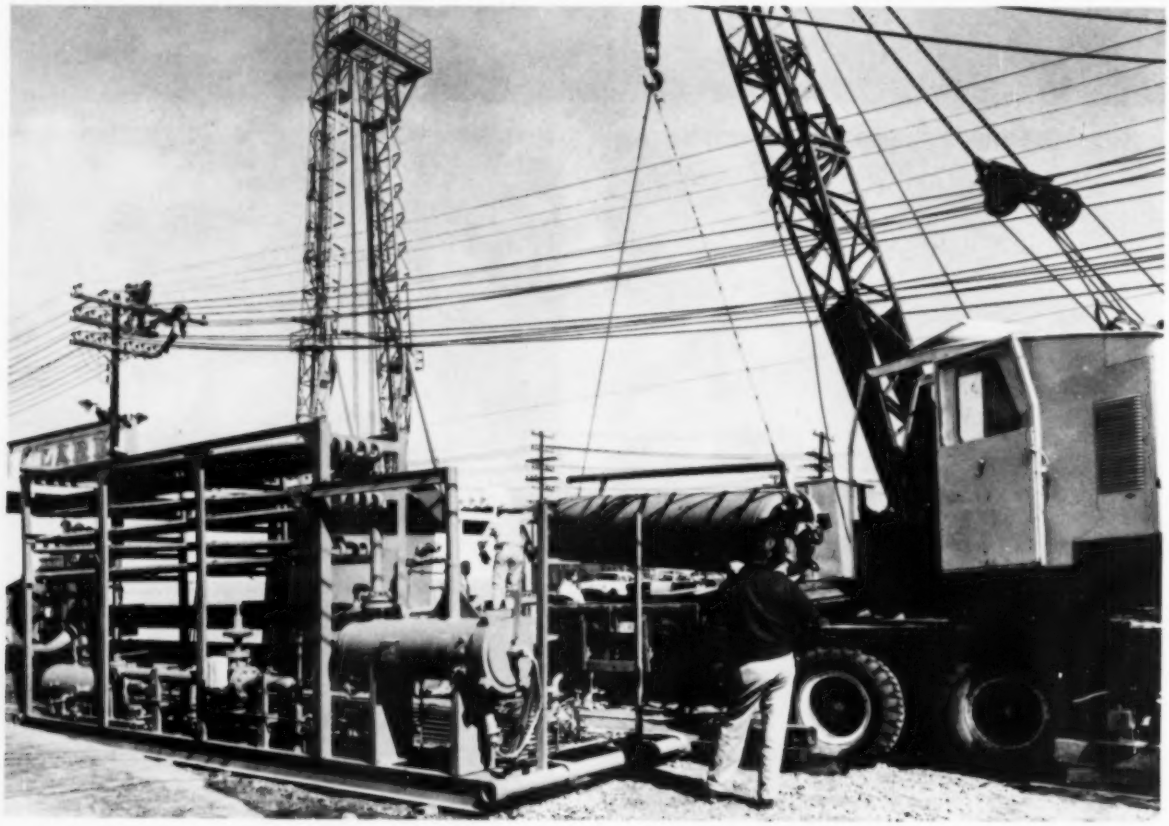


OKLAHOMA







B

Band-It Co.
Booths 82, 129
Industrial pressure clamps and auxiliary equipment.
Val Lodholm, Jack Evans, Jim Farkas, George L. Grimes, Ed Evans, Gene Blomberg, Tom Shore, Julian White, Fran Curtis, Bill Andrews, N. F. Rea, Leo Wargin.

Bowen - Itco
Block V
Mechanical and hydraulic rotary jars, Overshots, cutters, desanders, junk baskets (reverse circulation and standard), complete wireline wellhead setup, new depthometer, 20,000 lb segment type wireline valve, packer retriever, quick couplings for wireline tools.
Eldon Osmun, Cecil Greer, Ollie Turner.

The Brewster Company, Inc.
Silver Lane, Block # 10
Drawworks, new swivels, and rotary tables.
Harry B. Marioneaux, John L. Morgan, Bill Pickering, Cliff Williams, Mark Parker, J. D. Johnson, Jerry Upchurch, Ervin Auxter, Jerry O. Price, Tom Upchurch, Bill Hanaker, Joe Chambless, Tom Maughon, Zack Ford, Joe Dunlap, T. W. Griffith and Ray Dykes.

Briggs & Stratton Corp.
Booths 13, 14
Single cylinder, 4-cycle, gasoline engines — 2 to 9 hp.
E. V. Oehler, F. P. Stratton, J. H. Ebershoff, J. M. Sullivan, R. C. McWilliams, J. L. Joynt, J. P. Balding.

Brown Oil Tools
Texas Bldg. Booths 59, 60
New hydraulic set retrievable packer, other new packers.
C. C. Brown, Joe Brown, Ray Brown, John Feeser.

C

Cal-Metal Pipe Corp. of Louisiana
Kansas Bldg., Booth 80
Electric Resistance Weld Pipe Mill, 6-in. to 16-in. range.
John P. Stupp, Robert C. Stewart, John A. Preston, Robert E. Johnston, Jr., A. H. Davis, Virgil C. Gallman, Harmon Cutler, Douglas Leslie, G. L. Revell, Charles Babbitt.

Camco, Incorporated
Oklahoma Bldg., Booths 198, 199, 200
Gas lift equipment and wireline tools, particularly exhibiting new products: gas powered clock, storm choke, gas lift valve, rubber cup check, fullflow subsurface pump, time cycle controller with tubing cutoff.
Sam Pearce, Pat Childs, Charles Nevels, H. H. Moore, Jr., H. W. Winkler, M. G. McFall, J. D. Collins, Grady Hillman, Robert Linscomb, Jack Regan, Wm. P. Massey, George Camp, Dale Johnson, K. O. Robison, Fred Schnars, Betty Pfeiffer.

Cameron Iron Works
West Area — Block 115
Outside north door of Oklahoma Bldg.
Type F Blowout Preventers, pressure operated gate valves, graphic control panel, casing hanger, flow controlers and choke beans, solid block christmas trees, multiple completion christmas trees.
W. Roy Davis, W. L. Reynolds, R. F. Farmer, R. C. Brooks, J. H. Grubb, T. J. Waine, I. M. Baker, O. L. Lorehn, R. A. Zorn, D. C. Washburn, E. L. Barker, H. E. Brown, J. R. Jerabeck, T. G. Roscoe, W. H. Phillips, Radean Hallmark, F. H. Isaacks, J. M. O'Neill, J. B. Ray, T. C. Stedman, M. F. Sherrod.

Clark Bros. Company
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive
Skid-mounted compressor, horizontally-split centrifugal compressor, control panels: manually sequenced, electrically sequenced engine control, electrically sequenced engine and compressor control, spare parts for gas turbines, compressors.
J. N. MacKendrick, F. W. Laverty, G. W. Probst, R. F. Moser, E. G. Beardsley, R. E. Jenkins, R. J. Spears, F. D. Struchen, R. A. Chaffee, W. V. Pickering, R. M. Greene, T. P. Latimer, M. A. Moorman, G. L. O'Connor, T. J. Chruan, W. H. Payne, G. H. Beach, F. O. Henning, E. W. Tanzberger, K. W. Page, E. H. Flaherty, J. Bysarovich, C. N. Graff, W. F. Kane, J. H. Bews, Jr., J. B. Hickey, J. P. Miller, C. S. Caldwell, J. B. Williams, Richard Foster, A. G. Van Campen, J. Dzuback, A. R. Noak, J. N. Cooper, J. R. Hutton, W. E. Flagg, C. Fay Kenrick, R. C. McDonald, G. T. Merrick, Jr., R. W. Coons, A. H. Fix, R. J. Johnson, R. R. McCartney, M. J. Galpin, Hugh Harleston, Jr., S. C. Volpe, C. J. Michelson, J. E. McCarthy, J. A. Goodnough, IV, W. Dumar, W. L. Henshaw, V. E. Ford, R. C. Bergman, C. L. Dean, A. D. Nichols, D. G. Paul, B. J. Hardin, Frank Tidona, W. T. Durkin, J. W. Malone, C. P. Clark, Jr., W. A. Roever, E. G. Hotze, J. F. Allen, Jr., H. D. White, H. B. Cox, O. S. Roden, G. D. Smale, C. R. Apitz, S. L. Babbitt, Jr., R. E. Bailey.

Colorado Fuel and Iron Corporation
Oklahoma Building Booths 162-165
Hospitality center, secretarial and phone service, wire rope and tubular products.
F. S. Jones, J. N. Counter, A. S. Rairden, R. E. Metzger, W. W. Leonard, H. M. Dorward, J. H. Driggs, R. T. Dry.

Continental-Emsco Company
Corner of Drake and Oklahoma Drives
Heavy duty drilling rig with three engine drives; one engine by torque converter, another by fluid coupling, and the third by electric coupling; equipped with 142-ft mast and 10-ft substructure. Also includes traveling block, swivel, and rotary machine. A drilling rig powered by a gas turbine engine, trailer mounted mast, traveling block, and rotary machine. Traveling blocks and swivels, rotaries, unit pumpers, complete line of slush pumps, including four new models. Also displayed will be equipment manufactured by Chain Belt Company, Winwell Manufacturing Company, Telsco Fittings, and H_2Oil. Exhibition building will contain exhibits of equipment manufactured by Continental-Emsco, Youngstown Sheet and Tube Company, New York Belting and Packing Company, Broderick & Bascom Rope Company, New Bedford Cordage Company, Page Oil Tool Company, and Fibercast.
F. M. Mayer, F. I. Brinegar, W. T. Powell, D. M. Bailey, J. A. Mussler, W. C. Kinder, R. Hortenstine, Jr., H. E. Lowrey, A. A. Ashton, W. D. Craig, L. M. Bush, E. M. Fetzer, R. A. Brewer, G. R. Pike, R. A. Gentry, E. A. Dunn, R. L. Collier.

The Cooper-Bessemer Corporation
Corner Mid-Continent Dr. & Oklahoma City Ave.
New compact engine-compressor units, centrifugal compressors, electronic controls, power engines, V-angle gas engine compressors.
E. L. Miller, R. F. Lay, R. L. Boyer, S. E. Johnson, C. G. Cooper, F. M. Devin, C. M. Reagle, J. W. Reed, G. C. Woodard, G. W. Edick, W. R. Crooks, Arthur Abel, Jr., G. D. Adams, R. F. Bartlett, Jr., D. R. Bohannan, W. J. Burkstaller, A. A. Burrell, S. N. Campbell, R. H. Dale, W. F. Decker, F. A. Gehres, H. A. Graham, C. J. Havekotte, R. E. Hensley, J. R. Holloway, R. Humphreys, F. J. Hunter, T. M. Lamberth, F. W. Quiggin, L. L. Jones, W. H. Kraemer, T. E. Kraner, E. P. Martin, C. L. MacDougall, C. E. Neary, B. E. Perry, W. A. Rhoades, E. R. Rogers, A. Rothenbuhler, H. Sanders, O. W. Stanley, W. W. Waligore, R. J. Wheelock, C. W. Woltz, R. G. Williamson.

Cummins Sales & Service, Inc.
Mid-Continent Bldg. Block 3.
Engines and related control assemblies and products including a KW Electric set, air Actuator, air-gas starter, corrosion resistors, petroleum solvents, oil filters.
J. T. Calnon, L. J. Troutz, J. L. Peeler, J. B. Siegrist, H. B. Burr, R. J. Arroyo, C. E. Troutz, G. J. Van Dyke, A. C. Zugar, W. B. McColm, H. H. Hope and L. G. Kitchens.

D

Dresser-Ideco Company
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive
Scale model TV tower, material on oil field application of microwave towers.

Dresser Industries, Inc.
Dresser Bldg., Silver Lane at Skelly Drive
H. P. Boncher, M. R. Church, D. H. Curtis, J. P. Gasser, O. Hammer, H. A. Herzig, John Lawrence, Elwood Lindell, H. N. Mallon, M. D. Meyer, M. S. Miranda, L. H. Nordenson, J. B. O'Connor, G. H. Pfefferle, R. E. Reimer.

Dresser Manufacturing Division,
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive
Couplings.
S. D. Brown, E. R. Carey, M. Cleland, C. H. Evans, F. G. Fabian, W. Krueger, C. Kuhn, J. P. Lord, H. Peebles, W. H. Rowell, E. Stafford.

G

Gatke Corp.
California Bldg., Booths 23, 24, 25
Deep well woven brake lining and brake blocks.
Frank Gatke, Walter Berngen, W. O. Barton, Norman Radloff, J. Younglove, Lee Boswell.

General Electric Company (Carboloy)
North Area, Booth 39N
Carboloy cemented carbide.
Gerald Nolon, Ed Boersig, Grant Morrison, Raymond F. Parker, Leonard Budzen, George Hartley, William Reich.

The Gorman - Rupp Company
Silver Lane & Dawson Ave., Booths 20-22
Self-priming centrifugal transfer pumps, trash-sewage pump for mixing mud.
Gilmore Hiett, Warren Rupp, James C. Gorman, Donald Sanders, Gilbert Stahl, Ray E. Owens, George Erbe, Ralph Kurtzman, K. Jack Bargahiser, Dale McKinley.

Graver Tank & Mfg. Co., Div. Union Tank Car Co.
Kansas Bldg., Booths 74, 75
LACT systems, dehydration units, oil and gas separators, emulsion treaters, fluid boosters, metering separators, field-erected storage tanks.
Clark Root, J. E. Fogarty, W. B. Broxham, E. R. Fogarty, C. P. MacDonald, Henry McCabe, R. F. Millett, Jack Gray, E. G. Vail, L. G. Moreland.

Gray Tool Co.
Texas Bldg., Booth 15
Christmas trees, pipe connections, monel lined tubular goods.
J. W. Lemley, R. L. Crain, Grant Lawrence, Harlan Howell.

The Guiberson Corp.
One of the Dresser Industries
Dresser Bldg., Silver Lane at Skelly Drive
Tubing swabs, unions, wire line oil saver rubbers, drill pipe protector rubbers, shorty tension packer, down-hole separator, shorty packer tail pipe adapter, shorty production packer, pipe wiper, pump piston, cementing plug, drillable bridge plugs, drillable packer, chain drive blowout preventer, tubing spiders.
R. O. Cox, Morgan Crow, E. W. Davis, R. C. Davis, R. A. Day, D. L. Fry, G. G. Guiberson, William Horn, J. J. Lahe, Tom Losey, R. L. McAdams, D. L. McGill, P. E. Pierce, W. V. Phillips, J. E. Reagan, H. E. Simpson, A. P. Smith, L. W. Vessells, H. S. Zane, Jr.

Gulf Coast Machine & Supply Co.
Park Lane, Booths 7, 8
Christmas trees, automatic choke (constant tubing pressure), DMH split hanger, adjustable AB choke, positive RD choke, valves, rough industrial forgings.

C. H. LeBlanc, J. C. Newman, Tom Balmer, Cliff LeBlanc, Jr., Jerry Forcher, A. C. Van Cleve, Leonard Cowan, Huston Chapman, D. R. Etzel, E. C. Bird, E. V. Metcalf, L. P. Normand, I. D. Abshire, Don Fagan.

H

Hagan Chemicals and Controls, Inc.
S&T Bldg., Booths 83 and 84

Chemicals used to condition oil field water, water flood injection water quality control service.

B. Q. Welder, Ben Sloat, A. R. Ellenberger, John Hand.

Halliburton Oil Well Cementing Co.
Block K, East of Block K, West of Block K

Fracturing equipment and supplies: basic fracturing fluids, low fluid-loss additives, supplies for multiple fracturing, thickened fluids, propping agents, sand, scale preventer. Basic acid solutions, inhibitors. Water-control materials, surfactants. Cementing materials: basic cements, additives, lost circulation materials, accelerators, retarders, low water-loss additives, special products. Formation testing and special tools: retrievable squeeze packer, retrievable valve tester, running case for pressure recording gage, retrievable bridge plug, pressure chart display. Manufactured sales products: cementers, collars, shoes, centralizers, clamps, packers, setting tools, baskets, valves. Power-driven wire line measuring assemblies and accessories. New cementing unit, including cement densitometer for continuous measurement of cement slurries.

L. D. Campbell, L. B. Meaders, R. G. Kelly, W. D. Owsley, H. P. Conroy, H. P. Hearn, D. R. Yager, E. L. Paramore, R. R. Emery, J. G. Kilgore, R. O. Brown, R. M. Hansen, M. K. Brummett, J. P. Harbin, G. D. McEnroe, C. M. Roberts, J. Guest, D. H. Hathorn, C. E. Trapp, W. R. Coleman, J. W. Woods, H. W. Ayres, R. W. Graham, L. H. Thompson, S. J. Babin, J. M. Montgomery, G. S. Battles, T. T. Rogers, F. A. Johnson, C. L. Wimberly, J. W. Maly, R. W. Mitchell, R. B. Beddingfield, L. M. Boortz, O. L. Stalcup, W. L. Hughes, T. F. Phillips, P. C. Mayfield, J. L. McBride, H. L. Northcutt, J. O. Tillman, A. O. White, C. L. Bramlet, H. E. Gardner, W. L. Grossman, H. E. Doane, W. E. Hinchliffe, F. L. Patton, J. A. Banister, Jr., J. W. Hall, F. C. Moody, E. C. Lawrence, F. W. Nussbaumer, W. H. Denney, L. Leon, R. B. High, J. M. O'Gilvie, T. O. Roe, V. R. Young, Jr., J. B. Livingston, J. L. Muse, C. C. Christian, C. R. Durossette, C. L. Fulton, R. L. O'Bryan, F. J. Saye, B. W. Aulick, P. A. Liston, F. E. Vaughn, W. M. Baker, P. Patterson, B. H. Clark, F. N. Liscum, W. H. Burkleo, O. L. Bell, S. S. Westbrook, A. G. Bell, W. E. Hassebroek, F. M. Anderson, J. F. Mason, A. Fuentes R., W. B. McCoy, M. W. Reed, P. S. Vincent, M. D. Rasher, V. V. Gunn, B. D. Brown, L. F. Mermis, B. S. Haug, J. D. Thornton.

Hardy - Griffin Engineering Corp.
Texas Bldg., Booths 127, 128

Dual seal tubing joints.

W. H. (Buster) Becker, A. (Dutch) Zwenerman, Joe Safford, C. D. Mayes, W. L. Phillips.

Harrisburg, Inc.
Texas Building, Booth 96.
Mid-Continent Bldg., Block 3

Slush pump liners, rods and pistons. Tell tale assemblies. Gland bushings and junk rings, packing, gaskets, chain, rig wash compound, washpipe, resilient seal valve, drill collar lubricants.

J. E. Snoddy, R. T. Stewart, Ray Eastridge, Ted Nesky, John Brookman.

Herb J. Hawthorne
North Area, Booth 27N

Finger bits, 3 and 4 blade insert bits.

Bill Davidson, Burl Hawthorne, Jesse Stockard.

Heldie's Portable Pipe Service, and Heldie's Machine Works
Dawson St. Between V & Y

Special portable equipment to service oil country tubular goods, including stress-aligning tensile testing machines.

E. A. Heldenbrand, Paul Heldenbrand, A. P. Heldenbrand, Russell Heldenbrand.

Hercules Motors Corporation
California Bldg., Booths 7, 8, 9

Oil field engines, V-12 cylinder power unit; 6 cylinder 270 HP unit, and 255 HP unit.

W. L. Pringle, D. A. Otto, A. E. Bigelow, J. L. Biasetti, E. A. V. Horiak, W. F. Humphrey, T. S. Klinedinst, A. D. Marks, John Wilson, Walter Lightbourn, J. A. Embry, F. W. Ussery, J. E. Erwin.

Hughes Tool Company
Block 106

First 1909 bit, first cleaning cone bit, unit bit, tri-cone bit, tool joints.

G. J. Meyer, F. H. McElya, M. E. Montrose, D. J. Martin, W. H. Siems, L. L. Payne, P. L. Myers, E. M. Connor, R. G. Grant, H. B. Woods, J. R. Lesch, R. W. Lewis, O. B. Latrobe, R. G. Roberts, H. W. Harms, E. F. Baldwin, A. K. Babel, S. Hargon, R. D. Hood, A. P. Farr, Robert Nolley, W. W. Hampton, A. G. Rollow, J. A. Kloesel, R. A. Cunningham, H. T. Oliphant, K. R. Lord, F. E. Allen, R. R. Brownridge, J. W. Roach, S. R. Mays, P. H. Meeting, F. C. Radcliff, S. R. Chambless, P. E. Green, A. H. LeBlue, E. W. Hoeppner, J. P. Muller, A. F. Briscoe, W. P. Crosby, R. P. Aulick, L. B. Stinson, R. D. Jones, F. T. Alexander, T. G. Whiddon, H. M. Kelley, M. A. Foreman.

I

Ideco, Inc.
One of the Dresser Industries
Dresser Bldg., Silver Lane at Skelly Drive

Full-view mast, mud pumps, drive-in rigs, swivels.

G. W. Walton, W. O. Cook, G. G. Wilbur, W. M. Marks, Norman Dyer, Ellis Williams, John Eaton, Carl Weisenfelder, Robert Johnson, Mark Turner, Gordon Cain, Burton French, James Ashworth, Glen Clodfelter, E. J. McFadden, R. A. LaFleur, J. M. Drouet, L. K. Tipton, N. W. Fowler, W. K. Thorson, George Council, J. R. McPeak, James C. Bell, A. R. McLerran, J. R. Hilder, J. C. Young, J. E. McGuire, S. L. Matheny, Jr., V. L. Hawkes, R. N. Scriber, Allen Berry, E. F. Shiels, A. L. Woracek, John Pritchet, Rurgut Ulug, S. H. Barrett, C. W. Harrison, C. E. Wright, R. A. Feemster, Ed Kirby, C. S. White, W. J. Mallin, C. R. Athy, R. M. Perdue, Dan White, George Wharton, J. K. Hudgens, A. M. Blevins, Scott McCrary, W. F. Born, R. L. Pittard, Agnes Barnes, Ilene Hall, M. E. Horn, Clyde Bloss, N. F. Foff, Horace Branham, B. L. Price, W. W. Patterson, T. B. Bixler, J. E. Challis, W. C. Ready, W. J. Wallace.

J

Jones & Laughlin Steel Corporation
Block 1

Tubular goods, wire rope and containers.

Jones & Laughlin Supply Division
Block 1

Tubular goods, wire rope, valves, fittings, pumping units, slush pumps, sub-surface pumps, tanks, water-flood equipment, electric motors, mechanical rubber goods and oilfield supplies.

Rainey Elliott, W. L. Wolfe, L. G. Sutter, R. J. Woods, Jr., A. G. Bastian, W. O. Hardy, E. E. Storey, Jack Judd, W. R. Clarke, Henry Franks, C. E. Bogle, J. T. Batchelor, O. A. Bergmann, W. O. Kupper, L. B. Rainey, Jr., J. A. Tucker, G. A. McDaniel, D. T. Ottinger, F. L. McFarland, R. T. Bouldin, D. H. Carson, M. A. Park, V. H. Weldon, Jr., A. W. Hail, C. E. Rogers, A. G. Wehrley, C. H. Kellogg, W. M. Biddison, J. W. Johnson, W. R. Layne, A. A. Hopper, C. A. Nicklas, G. E. Best, W. J. Whatley, J. K. Guinn, H. H. Wilson, V. A. Hamilton, H. J. McAdams, L. W. Todd, R. J. Phibbs, G. A. Whiteker, H. C. King, F. W. Birmingham, P. V. Edwards, H. H. Ray, G. A. Pryor, H. L. Kymen, M. G. Burgeis, R. L. Daniel, C. P. Hudson, J. A. Carrigan, J. N. Larsh, L. P. Mackey, G. H. Garms, Jr., C. H. Maxwell, A. E. Penrose, R. A. Mercer, J. A. Beaird, R. Z. Dallas, D. T. Hamm, L. O. Bass, Jr., G. E. Tyson, O. M. Lorenz.

Justrite Manufacturing Company
Scientific & Technical Bldg., Booth 17

Safety flashlights and electric lanterns, new truck mounted portable electric lanterns, safety filling cans and oily waste cans.

C. S. Packer, R. Bearce, R. Ealem, R. Van, J. N. Grimshaw.

K

Ben F. Kelley Co., Inc.
Silver Lane, Booths 36 and 37

Safety spinning and breakout catheads, safety air operated rotary drilling drill pipe, casing and tubing slips, safety type "K" fulgrip tubing and workover tongs.

Ben F. Kelley, B. F. Kelley, Jr., Ray Sloan, Col. Parsons, E. C. (Ed) Prasuhn, C. M. (Pete) Peterson, M. O. (Mack) Webb, O. L. (Lee) Franks, G. Barney Blair, Ed Cowley, Marc Lamkin, Ray Cash, Carl Moulden, Dick Moyer, Marshall E. Niedecker, LeRoy Ducommun.

L

Lane-Wells Company
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive

Packers, bridging plugs, gun perforators, nuclear logging services, electrical logging services, nuclear activation logging services.

John J. Neale, Jas. D. Hughes, K. C. Gee, John H. Zauner, J. M. Miner, C. L. Kirkman, E. A. Radack, A. L. Boyd, M. C. Young, R. M. Rutledge, Jr., Ed Saye, III, W. L. Pugh, J. M. Terry, Dan H. McLendon, W. H. Redford, L. V. McConnell, N. H. Phillips, V. L. Lavin, H. D. Vaughan, J. W. Kiser, M. P. O'Haver, C. F. Ludwig, H. A. Metzger, D. R. Hoffman, R. L. Gregg, J. P. Myers, John L. P. Campbell, W. D. Bishop, J. J. Harper, A. W. Cook, F. O. Bohn, P. A. Pausky, N. J. Mellies, R. E. Jordan, W. E. McPhee, A. Venghiattis, L. D. Meddick, Lyle Dillon, R. W. Mayer, R. E. Bush, J. C. Jarrett, J. C. Wilson, D. E. Corley, J. M. Walker, C. Searcy, F. A. Taylor, J. G. Beaver, L. J. Lobdell, B. P. Loughnane.

Loffland Brothers Company
Block 13

World wide drilling services.

M

Magnet Cove Barium Corporation
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive

Various drilling mud samples, demonstration of mud engineering techniques, mud engineering test equipment.

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F. H. Maloney Company
Texas Bldg., Booth 14

Pipeline crossing insulation, pipeline casing end seals, thermometer wells, pump and compressor parts, high pressure tapping machines, flange insulation, scraper cups, insulated couplings.

D. A. Van Scoy, B. D. Coyle, Lyman Mathison.

Clayton Mark Company
Oklahoma Building, Booths 50 and 51

Unions.

William J. Dickman, Joseph Mikovich, Larry Funk, Carl Hanson, Joseph Lowey.

Mid-Continent Supply Co.
Blocks 3, 12, 13, 14

A complete line of oil field products and machinery including drawworks for every depth, compounds, tables, blocks, slush pumps, drive bushings, couplings, drilling line, lubricants,

catheads, kellys, standpipe fittings, tool joints, valves, bearings, circulating units, oil pumps, tongs, grinding wheels, blowout preventers, relief valves, swivel joints, unions, engines, whistle alarms, air starters, adsorption units, separators, heaters, rig lights, chain, electric motors, clutches, catlines, sheaves, swivels, wire-line measuring devices, pump liners, rods, and pistons, valves, vibrator hoses, shale shakers, weight indicators, drilling line hold downs, mast and substructure, hydromatic brakes, traveling block bumpers, deadline stabilizers, desanders, rotating heads, paint, hose and fittings, wireline guides, belts, hydra-hooks, elevators and links, and air controls.

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O

The Ohio Injector Company
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New valves.

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Otis Engineering Corp.
Texas Building, Booth No. 113
Isolation packer, dual flow choke, ball type safety valves, bomb hanger, surface recording bottom hole pressure or temperature gauge, bottom hole intermitters, drill pipe plug, dope squeeze service, tubing service, caliper service, sliding side door, selective nipples and related sub-surface flow controls, gas lift valves, tubing safety valve.

H. C. Otis, Sr., Robert H. McLemore, Herbert C. Otis, Jr., Lowell Wilhoit, Malcolm B. Roach, Dick M. Koons, Kenneth W. Robbins, Don F. Taylor, Jr., W. L. Hill, Jack Russell, Guy Gant, John Prejean, Charles LeMaire, Bob Crain.

P

Pacific Pumps, Inc.
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive
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Drilling mud centrifuges, desanders, mud pump valves and seats.

C. E. Church, C. P. Gillespie, Jr., E. O. Ernst, D. K. Gillespie, Al Beethe.

H. K. Porter Company, Inc.
Oklahoma Building, Booths 22, 23, 24, 25
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R

Republic Steel Corporation
Kansas Bldg., Booths 102-115
Casing and tubing, electric resistance weld and fusion weld line pipe, continuous butt weld pipe, plastic coated steel pipe and tubing, plastic pipe. Steel and Tubes Div.: tubing, electrical products, structural tubing, grooved tubing. Alloy and stainless steels. Containers, material handling equipment, fasteners.

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Rockwell Manufacturing Company
Science and Technical Building, Booths 33-38
Ball valve, round opening steel inverted plug valve, fixed adjustment gland, planetary gear operator for wrench operated valves, new stem construction for valves, special corrosive coatings, dual completion valves, recessed body valves, turbine meter, pointer meter and tank truck meter.

W. R. McLaughlin, E. D. Propps, R. G. Brennan, M. F. Shappard, F. A. Proctor, J. Dvoracek, G. G. Clayton, R. M. Farrell, T. C. Gerber, W. E. McDonald, E. E. Carlson, R. F. Crosson, G. A. Flynn, J. N. Holland, M. A. Bradburn, C. J. Landry, R. R. Bush, O. Cochran, C. T. Guffey, M. D. Gilbert, W. W. Shade, C. F. Kelly, F. J. McLane, Don Louvier, Wayne Renfro, J. E. B. Lundy, F. H. Neilson, George Schultheis, J. R. Frymire, O. W. Barnett, P. E. Cooper, H. Boezinger, R. B. Kitzmiller, J. H. Ohman, J. H. Walters, R. A. Johnson, C. J. Kentler, T. O. Carson, J. W. Harris, T. I. Stacy, A. J. Komich, H. M. Logan, H. Gottwald, J. L. Leisenring, W. J. Siedentopf, C. H. Chronister, W. F. Rockwell, Jr., L. A. Dixon, L. A. Dixon, Jr., P. C. Kreuch, W. T. Gettig, P. A. Manor, J. D. Bateman, W. F. Weimer, G. T. Bowman, E. Newman, N. E. Davenport, R. J. Sarraf, W. Richard Bleichner, E. E. Matheson, P. E. W. Goodwin, Jr., W. H. Muchnic, E. H. Sellers, G. F. Scherer, H. E. Rittenhouse, S. W. Brown, J. W. Bell, H. H. Fowler, R. B. Adams, M. T. Rowley.

Role Manufacturing Company
Block V (in connection with Bethlehem Steel)
Calcium chloride gas dehydrator, well checker, metering separator, meters.

R. K. Franklin, W. M. Boren, Bob Smith, Pat Clower, R. G. Oliphant.

Roots - Connerville Blower Div.
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive
Rotary gas meter model, high pressure gas meter, vertical rotary vacuum unit, various installation photographs.

G. H. Crocker, Bruce Feder, D. R. Fulton, D. B. Hutchcraft, J. L. Hylton, R. R. Newquist.

S

Security Engineering Div.
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive
New retaining nozzles for jet bits, regular line of rock bits, demountable hole opener, roller reamer-stabilizer, rubber stabilizer and casing scraper.

John C. Helies, C. L. Griffin, R. E. James, Leonard Busby, C. B. McDonald, Joe McGraw, W. C. Gray, T. H. Patterson, F. V. Walker, J. L. Dirks, Chester Frazier, J. R. Kelly, W. L. Kirby, F. J. Leonis, V. Mitchell, G. M. Charleston, M. L. Talbert, W. E. Scarborough.

Southwestern Industrial Electronics Co.
One of the Dresser Industries
Dresser Building, Silver Lane at Skelly Drive
Geodata system, combination portable system, field demonstration truck, TTR telemetering transceiver, dispatching console model, miscellaneous geophysical equipment, remote control demonstration, logging truck.

K. R. Beeman, Al Boynton, W. C. Dunn, A. B. Dustin, F. G. Gass, Rex Grey, M. C. Hester, John Joss, J. P. McGrew, C. R. McLendon, L. B. McManis, B. F. Mitchum, R. R. Paker, John Pink, E. A. Pratt, T. W. Russell, R. P. Watkins, W. R. White.

Stewart & Stevenson Services, Inc.
East of Block V
Diesel engines, industrial engines, oilfield utility unit, rig lighting plant, electric drive for rigs, sand frac unit.

N. J. (Tiny) Herman, Miles McInnis, Carsey Manning, Clem Mondy, W. E. (Bill) Powell, R. O. (Buck) Brehm, R. N. Conolly, N. N. Elkins, Dave Klager, Louis Duncan, Jack Conine, Grady Foster, H. A. Trotter, Joe Manning, C. L. Ward, W. E. Rutledge, Jack Price, Bill Foster.

Stratoflex, Inc.
Texas Building Booths 97, 98
Mid-Continent Building Block 3
Complete line flexible hose and reusable fittings.

C. A. Thomas, B. L. Matheson, T. J. Popken, B. M. Chandler, B. L. Ivey, J. C. Nolan, Dick Whipp, J. L. Tompkins, D. F. Howeth, J. P. Thomas and F. B. Hoenstine. Also T. C. Preston and L. W. Marshall from Stratoflex of Canada, Inc., Toronto, Ontario.

T

Turbodrill Division
Dresser Industries, Inc.
Dresser Building, Silver Lane at Skelly Drive
Cutaway model of turbodrill, demonstration of turbodrill.

Ed Bechtold, G. C. Jackson, John Jeter, J. A. Mitchell, R. W. Stuart, M. T. Works.

U

Unit Rig and Equipment Co.
Mid-Continent Building, Block 3
Drawworks, traveling blocks, engine compounds, rotary tables, complete drilling rig in operation.

J. L. Vint Jr., C. F. Southward, W. T. Pycke, F. C. Morton, E. A. Lyle.

U. S. Electrical Motors Inc.
North Area, Booths 67N, 68N, 69N
¼ to 200 hp electric motors and units.

W

Well Equipment Manufacturing Co.
Texas Building, Booths 101, 102, 103
Insulated union, union tubing wetbox, cleanout unit.

J. H. Robinson, John W. Gates, Foster Jordan, H. A. McCelvey.

White Diesel Engine Division
The White Motor Company
Block "L," Corner Oklahoma Drive and Mid-Continent Drive
Diesel, gas and dual-fuel drilling engines, gas engine waterflood package, gas-electric drilling unit, drilling engine 450-550 HP range, independent mud pump drive package.

J. H. Newton, G. L. Bader, H. F. Clark, P. W. Place, J. Seagren, H. W. Hanners, J. D. Stewart, C. E. Loyd, R. G. Alger, J. H. Simpson, L. L. Livesley, L. A. Gosden, P. E. Griffin, D. V. Carrington, E. H. Glascock, A. B. Reese, E. L. Penwell.

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THE PETROLEUM Engineer

FOR MANAGEMENT

NUMBER 5 • VOLUME XXXI • MAY, 1959

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Competition is in Incentives

A YEAR AGO we pointed out that the USSR was in direct competition with the Free World oil industry all along its vast perimeter (*The Petroleum Engineer*, July 1958). Since then the Soviet's plan of economic assault on the Free World has become obvious on several fronts.

And, how does the Communist government hope to win an economic struggle?

Certainly not by Marxian methods. Not by taking seriously the old Communist motto: "From each according to his abilities — to each according to his needs."

No, indeed. The Soviets are learning that personal incentives are the great revolutionizing force in economics. Realists that they are, they are using the same principles we once held dear and now allow the socialists in our own political scene to whittle away.

When smiling Nikita Krushchev, No. 1 Communist leader, appeared on our TV screens, he said "Your grandchildren in America will live under socialism." He may be right. We are headed in that direction. What he did not say was that by that time Russia's economy, headed in the opposite direction, may have incorporated more free enterprise in its economy than we have now.

In areas where Communist authorities have injected private enterprise features they have had their greatest success, says Arthur Lawson, once head of U. S. Information Agency (*Readers Digest*, April 1959). He adds that "the practice of relying on property incentives has become so thoroughly accepted in Soviet thought that Soviet leaders almost automatically turn to these methods when the need for increased production is urgent."

Reports from the USSR show that the income of scientists, engineers, managers, teachers is much higher comparably than salaries in our own country for those of equal professional status.

Incentives for U. S. private companies have eroded in constant battles with government and unions for control of some funds for expansion — some managerial leeway in which expansion and improvement are possible.

Said a man recently of the United States "We are living in the Age of Mediocrity." He saw no great leaders on the public scene. The most outstanding individuals of our time are scientists — most of them of foreign origin. The people of the U. S., he said, accept the mediocre, the middle-of-the-road, the secure.

What will be the outcome?

Will the Soviet take on our well proved incentives of income and profits at a faster rate than we renounce those same incentives? Unless the trends change, the curves will cross. We'll be the socialist nation and the USSR will be the free-enterprising one.

We buy intiative and leadership or we pay for mediocrity. The decision is in your pocket. Economic freedom will cost you more but timid security is never a bargain.

Ernestine Adams

Congrats and $25 to Billy D. Brown, T.P. Coal & Oil Co., P. O. Box 4067, Midland, Texas

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Lone Star is a round-the-clock quality operation. You can depend upon Lone Star API casing, tubing and line pipe.

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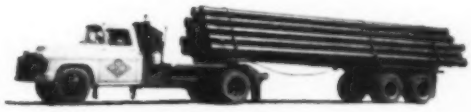

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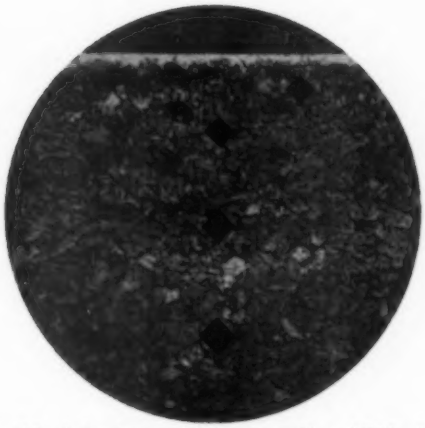
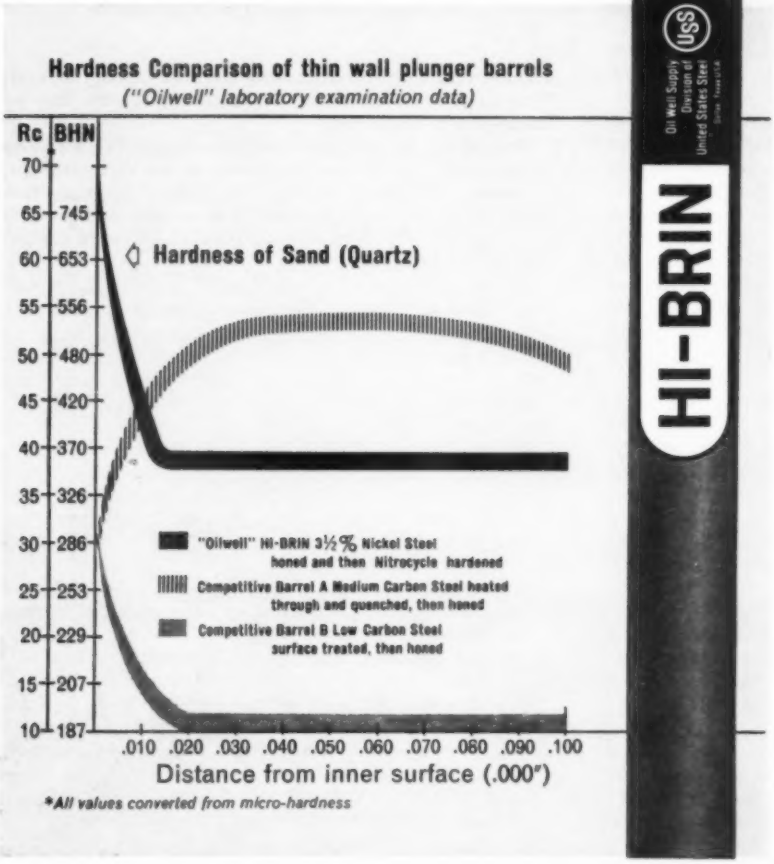
THIS INDEX IS PROVIDED AS AN ADDITIONAL SERVICE FOR OUR READERS—THE PUBLISHER ASSUMES NO RESPONSIBILITY FOR ERRORS OR OMISSIONS

"Oilwell" Hi-Brin Subsurface Pump Barrels are hard where it pays to be hard

. . . at the wearing surface!



LOOK . . . at this photomicrograph! A cross section of "Oilwell's" HI-BRIN Pump Barrel, magnified 250 times, shows the hardness of the barrel interior and the white layer of superhard nitrides. The smallest black impression made by the hardness tester shows a Rockwell "C" hardness of 68.



Examine this hardness comparison chart for a moment . . . and you'll see the performance secret of "Oilwell" Hi-Brin Subsurface Pump Barrels.

The secret is *controlled* hardness!

Compared with competitive barrels, the inside surface of Hi-Brin Barrels is harder to begin with . . . and STAYS harder right through the point (about .006" on the radius) where fluid slippage, due to wear, makes pump replacement necessary. Extreme hardness drops beyond this point . . . keeping intact the inherent toughness of the alloy steel tube.

Through "Oilwell's" exclusive distortion-free process, Hi-Brin Barrels are finish honed BEFORE hardening, so that the layer of superhard nitrides remains on each barrel's inner surface to greatly retard the rate of wear.

Hi-Brin Barrels are extremely resistant to hydrogen sulfide corrosion and to the abrasive action of sand. They contain 3½% nickel for extra toughness.

Contact your "Oilwell" representative or visit your "Oilwell" store for more information about Hi-Brin Pump Barrels. Try one in your next well. Your first Hi-Brin Barrel will certainly lead to more.

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Petroleum Profile

ASK ROBERT LEE MINCKLER how he got into the oil business and he'll tell you: "That was an example of careful planning. I was a purser on a ship and came into Los Angeles after undergoing 19 days of full gale. I decided I didn't like that business. I didn't know anybody in the city so I looked up oil companies in the yellow book. They were looking for people then. I got two job offers — both at $150 a month. I walked back and forth trying to get one of them to go to $155 and when they wouldn't I stopped about halfway between the two offices and tossed a coin to see which job I'd take."

This account is slightly apocryphal and General Petroleum Corporation can't conclude on this testimony alone that the gods of chance favor it.

The coin-tossing young man naturally went into the accounting department and the bookkeeping systems of that time were too staid and unrevealing for his curious and analytical mind. He developed a new system clear enough so even people who weren't accountants could understand it. The way he tells it, "I violated so many bookkeeping rules, I was made assistant to the president."

But where did he get all his ideas? Not solely from being purser on steamship lines. He'd had a variety of experience before he found his permanent berth. A northerner with a southern name, Robert Lee was born in Minneapolis. He went to high school in Williston Basin country, in North Dakota. Out of high school he got a job with the Great Northern Railroad in Montana.

World War I loomed and he took a turn in the U. S. Army. Then he must have decided that he could use some more schooling for in 1918 he enrolled in the University of Washington at Seattle and spent a few years on learning.

He'd been heading west all his young life and now he took another fling in that direction. He went to China on a tramp ship. All of which finally ended in the 19 days of gale and a land job.

Actually the first land job was as cost accountant for Southern California Edison Company. So Bob Minckler was no novice when in 1924 he became a cost accountant for General Petroleum Corporation. His post as assistant to the president extended to three presidents and his education continued (as doubtless did those of the presidents). John Brown, the first president he assisted, was a production man. The second one, Al Weil, was a lawyer, and Sam Dickey, the third, was an engineer. An employee who doesn't learn something from the boss isn't trying and Bob Minckler was.

In 1941 he was elected a director, in 1945 he became a vice president, in 1947 he was made executive vice president, and in 1948 he was named president of General Petroleum, which is a Socony Mobil affiliate.

"What is the key to success?" he is asked and facetiously he replies, "To look wise." And, like Hawthorne's Great Stone Face character, Robert L. Minckler has become a wise man. Why did he stay in the oil industry after his whirlwind turns with railroading, shipping, and utilities? "Energy consumption measures the standard of living and we are doing a job that increases the welfare of people." But that sounds too pompous. Minckler's personality is a kaleidoscope of whimsy and utter seriousness. "Where else can you risk a million dollars willingly one moment, hoping for a profit, and the next moment argue about ⅛ of a cent a gallon in price?" he asks.

Asked how it is that he knows so many top-ranking oil men on a first-name basis, he says the war did it. Two weeks after Pearl Harbor, he was called to Washington as Director of Oil Supply in the newly created Petroleum Administration for War. "I got to know most of them during the critical wartime oil shortages on the East Coast," he says, "and all of them before the fuel planning for the African landings was completed."

ROBERT L. MINCKLER
President
General Petroleum Corporation

One of the greatest pieces of our time is "Under New Management," a sweeping panorama of the economic philosophies that thread through the history of man. Bob Minckler wrote it, and delivered it as an address to several audiences in 1956. More than 30,000 copies were printed and mailed as a result.

To "What do you do on week-ends?" he answers, "Mostly loaf — and make notes." He shows a lined-sheet tablet with hieroglyphics that only his secretary can transcribe.

Some of these notes are written for his extensive work with management courses at several universities. At California Institute of Technology he is a trustee; at the graduate School of Business, Stanford University, he is a consulting professor of business management; at the University of Southern California he is a lecturer in business management; at University of California, L.A., he is on the advisory committee for the graduate School of Business.

Besides that he is a member of the important Advisory Board of the Hoover Institute on War, Revolution, and Peace; a trustee of the National Industrial Conference Board, and officer in a number of organizations.

He married Marguerite Hughes in 1926 and they have a married daughter, Mrs. C. F. Waterman, and a son, Robert Alan, a graduate of Stanford School of Business, who is now with the Security First National Bank.

Bob Minckler keeps alive the fiction that as president of a large corporation he has almost nothing to do (despite the fact that he seldom leaves the office until 6:00 p.m.). "I just walk down the hall and if anybody is working I go in and tell them they're doing a fine job."

That may very well be the key to success.

Automatic flame planer preparing edge of steel plate for eventual welding

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Process Equipment Division *Plate & Welding*

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A. End head being fitted to stainless steel inner shell 7 feet in diameter, as seen from inside outer tank jacket. **B.** Tank car 88½ inches in diameter being moved in Sharon plant by 25-ton overhead crane. **C.** Machine-cast manifold for 72 inch steam tube dryer being milled. **D.** Rounding up a stainless steel inner shell for a tank for liquid oxygen. Rounding ring (outside) and spiders (inside) adjusted to form perfect circle. **E.** Finished welded seam being x-rayed. Vessel being inspected rotates on power rollers. **F.** Heat treating operation in the General American plant at Sharon, Pa.

THE CONFERENCE TABLE

Better not invite trouble; it always accepts.

A Manager's Manager

Thompson, Viet-Nam president and Minckler.

Our Petroleum Profile this month, R. L. Minckler, president of General Petroleum Corporation, teaches several management courses besides doing an excellent job of managing his company. At the right is a picture of a group of General Petroleum men taking President Ngo Dinh Diem of Viet-Nam, through the company's Torrance refinery. Beginning at left are A. E. Thompson, manager of General Petroleum's Torrance refinery; President of Viet-Nam; and back of him the secretary of state for Public Works and Communications. At right is Mr. Minckler.

An Unconvinced Stockholder

Senator Young (D-Ohio), who votes for a 15 percent cut in depletion and says he will continue to, listed his stocks recently and he was a heavy investor in oil. He makes a strong argument for explaining the oil business to shareholders. Here are the ones who should send some literature to him. He owns 100 or more shares in Plymouth, Ashland, Socony, Phillips, Atlantic, Sinclair, Getty, Pure, Monterey, British Petroleum, and Equity.

Broadcasts Annual Meeting

For the first time the American people and company stockholders were able to hear an annual meeting of stockholders when American Machine & Foundry Company broadcasts highlights of its meeting over the NBC Radio Network, it was announced by Morehead Patterson, AMF board chairman.

The meeting was recorded and important portions were broadcast over the radio network on a 25-minute program entitled "This is AMF—Stockholders' Meeting on the Air."

AMF pioneered in another unique form of stockholder communication in 1957 when it was the first company to use inter-city closed-circuit large screen TV to televise the annual meeting in New York to a gathering of stockholders in Chicago, with two-way audio-visual communications maintained throughout the meeting.

★ *Great minds discuss ideas, mediocre minds discuss events, small minds discuss personalities.*

Import Decree Results Named

The new government curb on oil imports will have a number of far-reaching effects on the industry. Business Week lists major possible results as follows:

1. Prices both of domestic crude and of finished products will be under pressure to rise.

2. If domestic prices climb, the result could be fatter profits for integrated domestic companies and domestic crude producers — and thinner margins for the big international outfits.

3. With the U. S. importing less oil, skittish foreign prices may plummet further. Oil-producing nations such as Venezuela and the Arab countries may then demand a bigger share of company profits to maintain their revenues.

4. U. S.-flag tankers should enjoy a sizable pickup in traffic, since only they are authorized to haul oil between U. S. ports. But foreign-registry ships now handling imported oil will be idled.

5. Finally, the industry fears import controls might be the first step toward more government intervention, perhaps even including regulation of crude and product prices.

The greatest beneficiaries of the program should be some inland refiners. Most of them applied for import allocations even though by far the majority had never imported before. They can't sell the allocations outright, but they can trade their quota of foreign oil for domestic crude — and probably reap a tidy profit from the internationals in doing so.

★ *The past cannot be changed, the future is still in your power.*
—Hugh White

Pay for Red Scientists

After writing the editorial on Page A-4, we saw a news report that said scientists were going to be judged on merit rather than education.

The Soviet Union's elite army of scientific workers was warned that the mere possession of a doctor's degree no longer would guarantee the holder a lifetime in the nation's top salary brackets.

Drastic changes in the system of wages and payments to the scientists, based on the quality of their work rather than on their doctorate titles, are being drafted.

So the Reds move more strongly toward incentives based on results — the capitalistic method that works so well.

★ *God gives every bird its food, but He does not throw it into the nest.*

Mandatory Imports Approved

Representatives of the Liaison Committee of oil producing associations highly commended the imposition of the mandatory imports program by the Eisenhower administration, and called it "absolutely essential to national security." Hope was expressed that early improvement would be experienced in restoring adequate exploration and drilling activity. Read the statement: "We believe that there is no sound basis for criticism of the program as injurious to free-world source countries, and are convinced that it will be generally recognized as essential to the objective of oil security for America and her free-world allies."

How Many Live on Government Money?

A fantastic total of more than 35 percent of the nation's population today depends to a full or considerable degree for its subsistence on money paid out by all forms of government in the United States. The amazing conclusion was drawn this month in a survey published by the Baxter International Economic Research Bureau.

Disregarding any government support which agriculture or other industry receives, the survey came up with these figures:

Number of People Living on Government Money (November 1958)

A — Government Employees		
Federal, Civil	2,194,000	
Military	2,627,000	
State and Local	5,831,000	
Total	10,652,000	
B — Unemployed, Receiving Some Support		
State and Bureau of Employment Security Programs	1,556,000	
Temporary State Programs	409,000	
Veterans' Unemployment Programs	60,000	
Total	2,025,000	
C — Defense Business, Ten Percent of Non-Agricultural Employees	5,896,000	
Total A, B, C		18,573,000
D — Social Insurance and Welfare Services		
For persons 65 and older— Old Age and Survivors' Insurance, Railroad Retirement, Veterans' Pensions, etc.	8,500,000	
Miscellaneous aid to dependent children, the blind, disabled persons, etc.	3,312,000	
Total	11,812,000	
Total A, B, C, D		30,385,000

Projecting the percent of all Americans to the total number of workers, employed or unemployed, a total of more than 62 million Americans — or more than one in three — is shown to be indebted to government for the major part of subsistence.

From Reese H. Taylor's letter to employees of Union Oil Company of California.

New Fringe for the Fringe

Employers were asked to finance the psychiatric treatment for clerks in California's retail food stores. This appears to be a very interesting fringe for those on the fringe. But the coverage is far too limited. What about the manager who is carrying on under hectic conditions and what about the customer tied up in frustration?

In fact there's no end to the coverage. After the retail food trade is taken care of it could spread to other businesses — and to government, too. Who needs this benefit more than the diplomatic corps? Then, perhaps when our military and economic aid funds are distributed abroad we should add psychiatric benefits for foreign countries.

Of course, we always get back to that eternal question, who is going to psychoanalyze the psychiatrist?

Tips on Public Relations

Below are suggestions on public relations reprinted from *PR Reporter*:

Tips for improving your relations with the press:

1. See the right person on the newspaper, radio or television at the right time. Don't take up their time when they are close to deadline.

2. If the press asks you for information and gets it quickly and without qualifications, they'll use it. If you give any misinformation, you'll probably be written off as a news source.

3. If you approach the press, don't be offended when they check your story and perhaps add editorial viewpoints. That's their job.

4. Be sure the story has news value and deserves press attention before approaching them.

5. Contact the press personally whenever possible. Mail releases only if forced to do so and try to follow-up mail releases with personal calls when time becomes available.

6. Keep your stories or quotes brief and to the point.

7. Never ask or expect to be shown an advance copy of your stories. The editor feels he has a staff qualified to write the story correctly with the facts you provide.

8. Furnish photographs when appropriate and attempt to provide different pictures for different media.

9. Use news conferences sparingly. Save them for the big stories.

Tips on developing a PR program:

1. Make a thorough study of all operations and get opinions from various publics.
2. Evaluate your findings.
3. Outline your objectives.
4. Translate into a clearly stated policy.
5. Tell your hope of success.

Tips on how to sell the program:

1. Get the manager or president on your side and have him say so to the board.

2. Have the board president present the main points of the program and ask you to fill in the details.

3. Try to consult a few board members in advance and get them on your side.

4. Make the presentation short.

5. Emphasize the problem to be met and not the program.

6. Stress objectives.

7. Use few and simple charts.

8. Skip the PR jargon.

Tips for dealing with radio and television newsmen:

1. Try to tell them in advance which portions of a speech or which parts of the program are most important and most newsworthy.

2. Bear in mind that it takes more time to set up cameras and recorders than it does for a newspaper reporter to be on the spot. Try to give radio and television adequate time and advance warning.

3. Certain shows can use tapes or film clips. Explore your ideas in this respect with the news editor or reporter.

★ *The only people who achieve much are those who want knowledge so badly that they seek it while the conditions are still unfavorable. Favorable conditions never come.*

—C. S. Lewis

Highlights ★ ★ ★

They Want More Gas

Gas equipment sales — for houses and business — will top the 1958 total by nearly 15 percent, announced the Gas Appliance Manufacturers Association. February's shipments showed range deliveries up 16.4 percent, residential heating equipment up 34 percent, water heaters up 12.1 percent. Evidently they are going to want gas for this equipment. Is gas production going up? It didn't in 1958.

Reverses Crude Price Trend

Union Oil Company of California has increased its posted prices on Four Corners crude by 70 cents per bbl. This reverses the reduction made one month before, March 1, of 60 cents a bbl in the area. The company also announced its posted prices for California crude oils are increased from 1 cent per bbl for 15 deg gravity crude up to as much as 60 cents per bbl for 40 deg gravity crude.

Sunray Bids for Suntide

Sunray Mid-Continent Oil Company will offer to all stockholders of Suntide Refining Company, Corpus Christi, Texas, an exchange of one share of Sunray common stock for three shares of Suntide common stock, it was announced by C. H. Wright, chairman. Conditions are that Sunray Mid-Continent obtain enough shares so it will own not less than 90 percent of Suntide.

Incentives for Companies

A chart prepared by the Department of Commerce shows that the nation's products were valued $179 billion higher in 1958 than in 1947. Of this increase, $125 billion was attributed to higher wages, $27 billion to higher taxes and $27 billion to other factors. Thus hikes in wages and taxes accounted for 85 percent of the rise. In this period, corporation profits remained about the same. As we said in the editorial (Page A-4) company managements need some resources with which to build if they are to provide the jobs needed for an "exploding population."

Steel Mentions Wage Rise

Robert C. Tyson, chairman of United States Steel Corporation's Finance Committee, has a word to say about the coming steel contract negotiations. He warned of the inflationary effects of granting an "unearned" billion dollars to any segment of our economy. "If a group of people gets a billion dollars more they will spend more — no argument. If a group of people gets a billion dollars less they will spend less — again, no argument. There is no way for the steel union group to get an unearned billion dollars more without others undeservedly getting a billion dollars less — except that an additional billion dollars be, in effect, printed up, and this is pure inflation. But if one gets more and another gets less, the total is unchanged. The notion that, by robbing Peter to pay Paul, the real purchasing power of Peter plus Paul will be increased is, in the vernacular, pure bunk."

Hires Political Manager

Need for individuals in corporate management to face up to their political responsibilities, and to have their voices heard as individuals on issues which pose a threat to the best interests of American industry, was stressed by L. F. McCollum, president of Continental Oil Company. His statement was issued coincident with the appointment of Harold S. Skinner, associate general counsel, to the newly created position of assistant to the president and director of public affairs.

"Business corporations, as such, cannot engage in political activity," said McCollum, "but it is the responsibility of management as individuals to defend their companies in the political clinches and on issues which have a vital effect upon American industries." He concluded, "I should like to emphasize that any political action we undertake will be strictly on an individual and non-partisan basis. Members of Continental's management expect to actively interest themselves in issues which affect the company and the oil industry in general."

Want to Buy Nuclear Materials?

W. R. Grace & Company, Davison Chemical Division, has issued a price list for some of the nuclear reactor feed materials which are processed in the company's new plant at Erwin, Tennessee. It is believed to be the first price list for such materials to be published by a private concern. Here is what you can buy:

*Natural uranium metal	$ 24.00/lb
*Depleted uranium metal	4.85/lb
*Depleted oxide	3.30/lb
1.6 percent enriched uranium metal	5.60/lb
1.6 percent enriched uranium oxide	6.75/lb
25 percent enriched metal	65.00/lb
Highly enriched oxide	100.00/lb

*Prices for outright sale; other prices are conversion charges since only the Atomic Energy Commission can own enriched uranium.

Pricing Heads for "Fixing"

On one side the S.11 bill to establish "Fair Trade" prices has weakened opposition. A law by which manufacturers will set retail prices might be passed. On the other side are the anti-trust laws to assure strong competition that makes price maintenance conspiracies illegal. It will take balancing on a tight pricing rope to keep from offending some regulation. Senator Kefauver has a rerun on the S.11 hearings. Several major companies favor the bill as a means of relief from price wars.

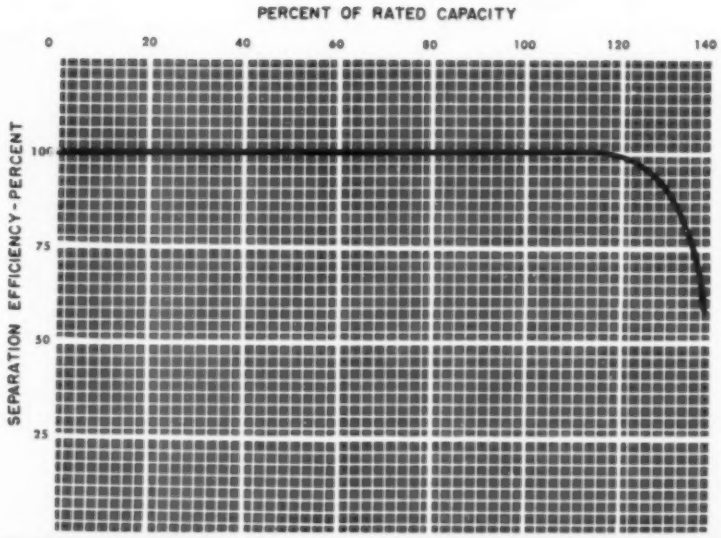
Retreat From State Companies

Shares in a state-owned mining company in West Germany put on the market were over-subscribed. The West German government has decided that public ownership of $1.7 billion in industries is incompatible with the free enterprise policies that have produced its great economic rise since the war. The stock was sold only to individuals with incomes under $3840 a year and was limited to 5 shares per person. Other sales of industries—including Volkswagen —are planned.

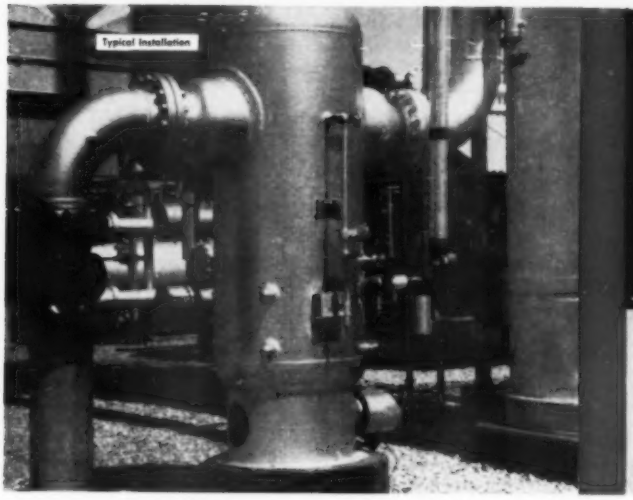
World-Wide Petroleum Equipment

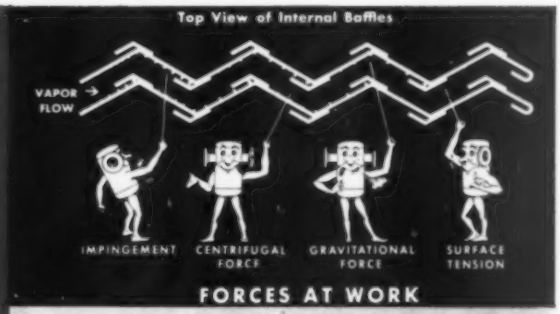
At the Fifth World Petroleum Congress Exposition exhibitors from Europe will vie with those from U. S. to show the latest developments in equipment for the industry. British, French and other manufacturers are bringing in their newest equipment. One exhibit will include rocket launching pads. It promises to be a real show — for science-fiction writers as well as the petroleum industry.

FLAT EFFICIENCY CURVE with PEERLESS Separators...



with Peerless Separators you can remove entrained liquids from process vapor lines and maintain a high efficiency over the entire range of flow.





FORCES AT WORK

The above illustration shows a top view looking down at two of the many internal separator baffles. Entrained liquid droplets are caught in the pockets and drained down out of the gas flow . . . thereby completely stripping the gas before it leaves the mist extractor.

PEERLESS MFG. CO. DALLAS, TEXAS

PEERLESS MANUFACTURING COMPANY

P.O. Box 13165 Dallas, Texas

Representatives in All Principal Cities

OTHER OUTSTANDING FEATURES OF PEERLESS SEPARATORS

- **Low pressure drop across mist extractor — less than 6″ of water.**
- **Compact and economical.**
- **Vane units can be made easily removable.**
- **Mist extractor and vessel can be made of any type material. Carbon steel mist extractors can be placed in a vessel and stress relieved without damage.**
- **Can be designed for any capacity or special requirement.**

OVER 20,000 SEPARATORS and SCRUBBERS IN SERVICE

Highlights ★ ★ ★

Pemex President Visits U. S.

President Gutierrez Roldan

Mexican industrial "ambassador" Pascual Gutierrez Roldan, newly appointed President of Petroleos Mexicanos (Pemex), addressed a group of 500 leading oil men in Dallas last month. A guest of Dresser Industries, Gutierrez Roldan talked in behalf of even greater industrial relations between Mexico and U. S. oil interests. He was introduced by Oklahoma's Governor Edmondson.

The Name Is Familiar

Stockholders approved a proposal to change The Texas Company's name to Texaco. It is called that by a substantial number already. The new name was formally taken on May 1.

Stock Deals

Directors of Continental Oil Company and San Jacinto Petroleum Corporation have approved the agreement under which Continental will acquire a two-thirds interest in San Jacinto, according to a joint announcement by L. F. McCollum, president of Continental, and Benno Schmidt, president of San Jacinto.

Directors of Sunray Mid-Continent will exchange one share of Sunray common stock for each three shares of Suntide Refining Company common stock. Sunray will make the offer provided that a sufficient number of shares of Suntide common stock are tendered on the exchange, within the time designated, to enable Sunray to be the owner of not less than 90 percent of all of the issued and outstanding common stock of Suntide.

Skelly Oil Company and Tidewater Oil Company are negotiating on a merger. Both Tidewater and Skelly are controlled by Getty Oil Company through intermediate holding companies. If the two big oil concerns should merge, the surviving firm would rank high among major petroleum companies in this country. Skelly had assets at the end of 1958 of $380,080,240, and Tidewater $810,731,000.

"Oil Woman of Year" Chosen

Elizabeth Bridgeman

A fuels technologist in the research and development department of Phillips Petroleum Company, Bartlesville, is the "Oil Woman of the Year" — and will be honored as such at the International Petroleum Exposition.

Mrs. Elizabeth Aldrich Bridgeman is the winner, chosen by a panel of top oil industry executives. The Desk and Derrick Club of Tulsa was the sponsor of the contest, in cooperation with the IPE.

Receiving honorable mention in the contest were Miss Irma Cline, owner of Petroleum Business Services, Hobbs, New Mexico; Mrs. Bernice W. Cleere, oil editor, Standard-Times, San Angelo, Texas, and Mrs. Margaret Applegate Kitchen, senior geologist, Sun Oil Company, Mount Pleasant, Michigan.

This is the second IPE "Oil Woman of the Year" award. The first went to Ernestine Adams of Dallas, management editor of The Petroleum Engineer, at the 1953 exposition.

Mrs. Bridgeman, holder of a master of science degree from Tulane University, New Orleans, is credited with many contributions to the industry. She has authored or co-authored 27 papers analyzing the fuel gum and vapor pressures which are characteristic of gasolines under various conditions in the automotive and aviation fields.

Meetings

May 18-20—**Instrument Society of America**, 1959 fifth annual symposium, Shamrock-Hilton Hotel, Houston, Tex.

May 25-28—**American Society of Mechanical Engineers**, design engineering conference, Philadelphia Convention Hall, Philadelphia, Pa.

May 27-29—**Gas Technology Short Course**, Texas College of Arts and Industries, Kingsville, Tex.

May 27-30—**API Division of Refining**, mid-year meeting, Statler Hotel, New York City, N. Y.

May 31-June 6—**Fifth World Petroleum Congress**, Coliseum, New York City, N. Y.

June 2-4—**Appalachian Underground Corrosion Short Course**, University of West Virginia, Morgantown, W. Va.

June 3—**National Petroleum Radio Frequency Coordinating Assn. meeting**, Mayflower Hotel, Washington, D. C.

June 4-5—**American Petroleum Institute, central committee on radio facilities**, Mayflower Hotel, Washington, D. C.

June 7-12—**API Division of Production**, mid-year committee conference, Brown Palace and Cosmopolitan Hotel, Denver, Colo.

June 9-10—**Petroleum Electric Power Association**, annual meeting, Hotel Galvez, Galveston, Tex.

June 10-13—**American Association of Petroleum Landmen**, annual convention, Skirvin Hotel, Oklahoma City, Okla.

June 14-19—**Society of Automotive Engineers**, summer meeting, Chalfonte-Haddon Hall, Atlantic City, N. J.

June 15-17—**Interstate Oil Compact Commission**, midyear meeting, Roosevelt Hotel, New Orleans, La.

June 22-24—**Canadian Gas Association**, annual meeting, Empress Hotel, Victoria, B. C., Canada.

June 24-25—**Western Petroleum Refiners Assn.**, Mid-Continent regional technical industrial relations meeting, Broadview Hotel, Wichita, Kan.

Aug. 9-12—**ASME-AIChE**, heat transfer conference, University of Connecticut, Storrs, Conn.

Aug. 10-13—**Society of Automotive Engineers**, West Coast meeting, Hotel Georgia, Vancouver, B. C.

Sept. 15-17—**Texas Mid-Continent Oil & Gas Association**, annual meeting, Rice Hotel, Houston, Tex.

Sept. 16-18—**National Petroleum Association**, annual meeting, Traymore Hotel, Atlantic City, N. J.

Sept. 20-23—**American Society of Mechanical Engineers**, petroleum mechanical engineering conference, Rice Hotel, Houston, Tex.

Sept. 23-24—**Western Petroleum Refiners Association, Rocky Mountain regional technical-industrial relations meeting**, Henning Hotel, Casper, Wyo.

Sept. 27-30—**API**, executive committee of board of directors, Greenbrier Hotel, White Sulphur Springs, W. Va.

Sept. 29-30—**Western Petroleum Refiners Association, management seminar**, Western Hills, Wagoner, Okla.

Oct. 4-7—**Society of Petroleum Engineers of AIME**, annual fall meeting, Dallas, Tex.

Good Wells Make Good News

A Monthly Report on Wells That Are Now Worth More

May, 1959

Every day Dowell engineers develop profit-building new ways to use acid to help operators get better production from oil and gas wells. Here are four examples:

- **St. Landry Parish, South Louisiana** (Old Gas Well) Production from the tight Miocene sand between 9533 feet and 9543 feet was only 1600 mcfd, with 62 barrels of distillate per million. With the help of the Dowell engineer, the operator selected a treatment consisting of 2500 gallons Super Mud Acid and 1500 gallons 15 per cent inhibited acid. Both acids had a Dowell silicate control agent added. This treatment was selected because of past success using about 200 gallons Super Mud Acid per foot of pay. After clean-up, gas production rose to 2400 mcfd. The $1725 treatment paid out in two weeks.

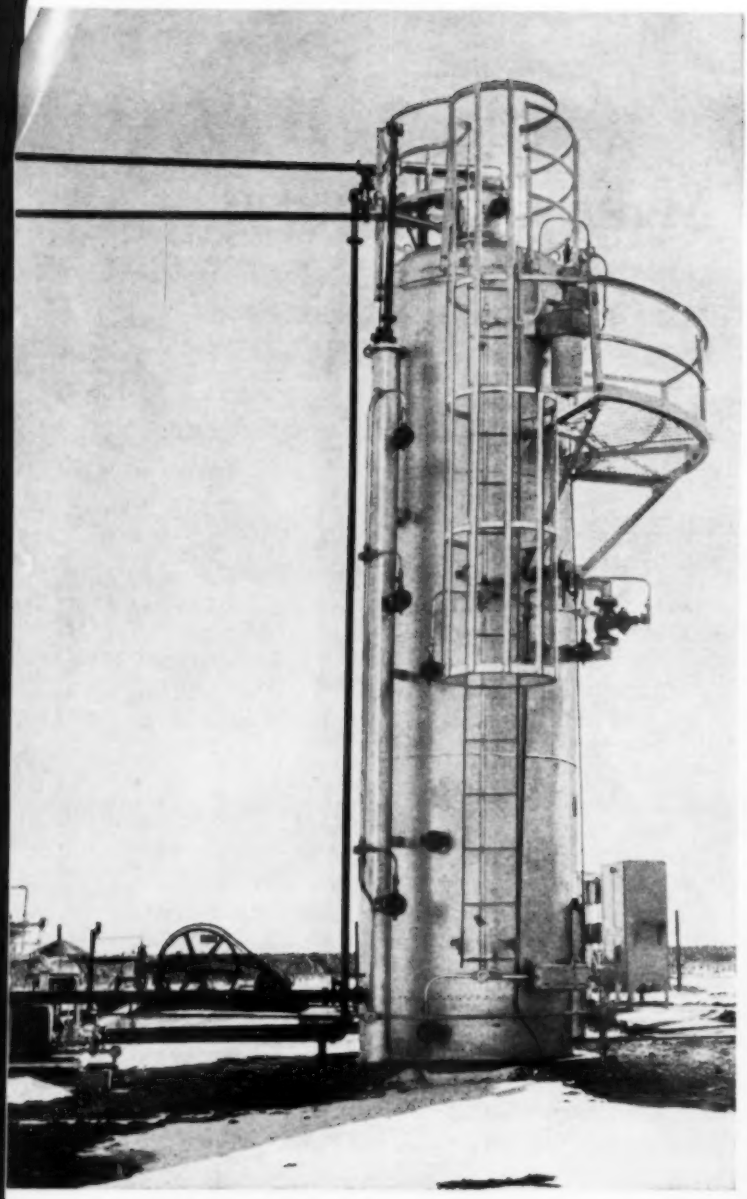
- **Hansford County, Texas Panhandle** (New Gas Well) This wildcat was completed through perforations from 6535 to 6546 feet. Producing zone was the Atoka lime. Before treatment, the well tested 1250 mcfd. Dowell acidized using two strengths of acid with silicate control and demulsifying agents added. 5000 gallons of 7½ per cent acid was followed by 6500 gallons of 4 per cent. Treatment was down casing at 9 bpm. After well had cleaned up, it tested 4000 mcfd.

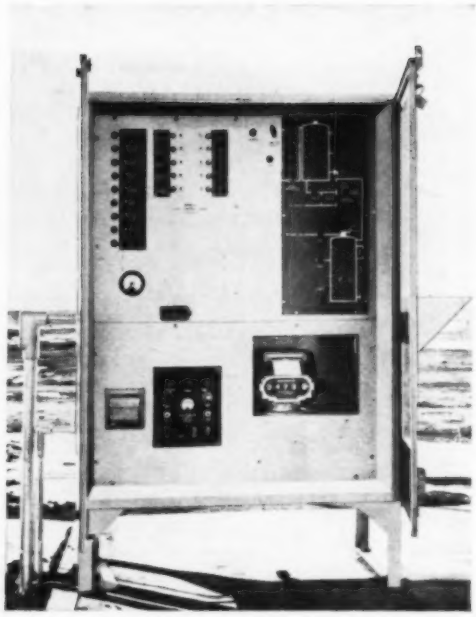
- **Carter County, Oklahoma** (New Oil Well) Before treatment, this well tested only a show of oil. It had been completed into the highly reactive Upper Chimney Hill lime from 7912 to 7922 feet. The operator called Dowell. 7500 gallons of Retarded Acid were used in a treatment to open up a larger drainage area. After clean-up, the well tested 14 boph.

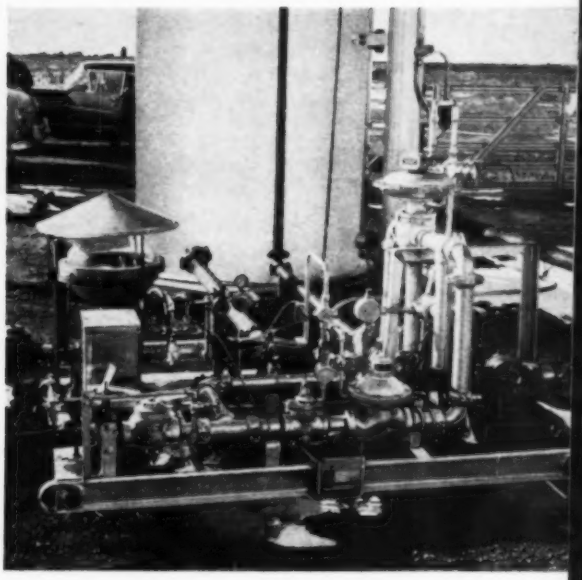
- **Southern Alberta, Canada** (Water Disposal Well) This old oil well was originally completed open hole in the Madison dolomite from 8557 to 8790 feet. After depletion, the operator wanted to convert it to water injection, but well would not take water at 2000 psi. Well was corroded. Also iron hydroxide precipitate had resulted from previous acid jobs, and deposits of paraffin and other heavy hydrocarbons were suspected. To treat all problems simultaneously, Dowell recommended Stabilized Acid and magnesium pellets. 300 pounds of pellets in gelled water were followed by 1000 gallons Stabilized Acid. After clean-up, well took water on vacuum.

In some wells, tailored acid treatments by Dowell have succeeded where all other stimulation efforts have failed. Whatever your production problem, call your Dowell representative. He may be able to save a well that would otherwise be abandoned. For full information, call any of the 165 Dowell service points. In Canada, call Dowell of Canada, Ltd.; in Venezuela, United Oilwell Service. Dowell, Tulsa 1, Oklahoma.

Services for the oil industry DOWELL
DIVISION OF THE DOW CHEMICAL COMPANY







CONTINUOUS FLOW OF METERED OIL!

This newest addition to the BS&B PHANTO-GAGER line of LACT units was recently put into service on a Texas Panhandle lease. Unlike other positive volume type metering systems, this unit has the unique advantage of delivering a continuous flow of metered oil to the pipeline.

In addition to eliminating the cycling of the pipeline pump, this PHANTO-GAGER, because of its completely closed system, conserves more of the lighter hydrocarbons and increases the gravity of the crude delivered. It also eliminates the necessity for additional crude storage facilities.

Your BS&B Man will gladly help you work out details for a similar installation on your lease. Why not call him now?

EFFICIENCY OVER 60 YEARS RELIABILITY
BS&B
ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC., DEPT. I-C5

P. O. BOX 1714, OKLAHOMA CITY

What we already know about your 1963 car

The engine of your 1963 car will be lighter and will give you improved performance . . . including better gasoline mileage.

We know this because Standard's scientists are already developing gasolines of the future. To test them, we use experimental engines installed in current model cars. The engines are obtained from auto makers and modified in our laboratories to match engine design forecasts.

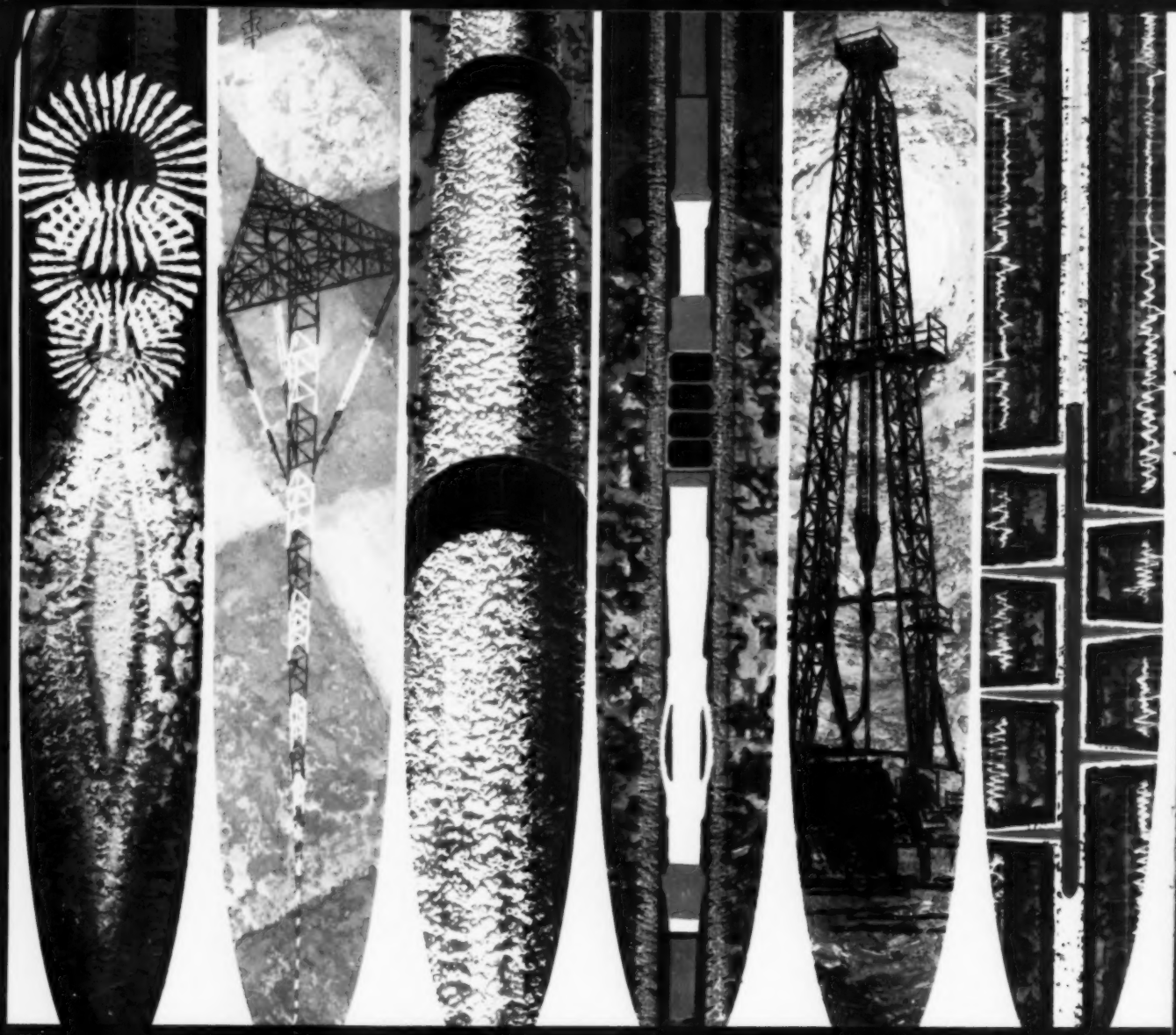
These future fuels get the toughest possible workout — on the road, as well as on this "indoor highway." Here, at the touch of a button, we can create almost any kind of weather or driving situation a car might encounter.

Gasolines are tested at varying speeds and engine loads to simulate mountains, traffic and freeways . . . under climatic conditions ranging from 120° desert heat to 40° below zero cold.

Your car of the future may never take such punishment. But if it does, we'll be ready with gasolines that will deliver all the power and performance built into its engine. Research that leads to new and improved gasolines is one of the ways ***the people at Standard are planning ahead to serve you better.***

STANDARD OIL COMPANY OF CALIFORNIA

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



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INTERNATIONAL PETROLEUM EXPOSITION

May 14 to 23, 1959

Tulsa, Oklahoma

(Silver Lane at Skelly Drive on Exposition Grounds)

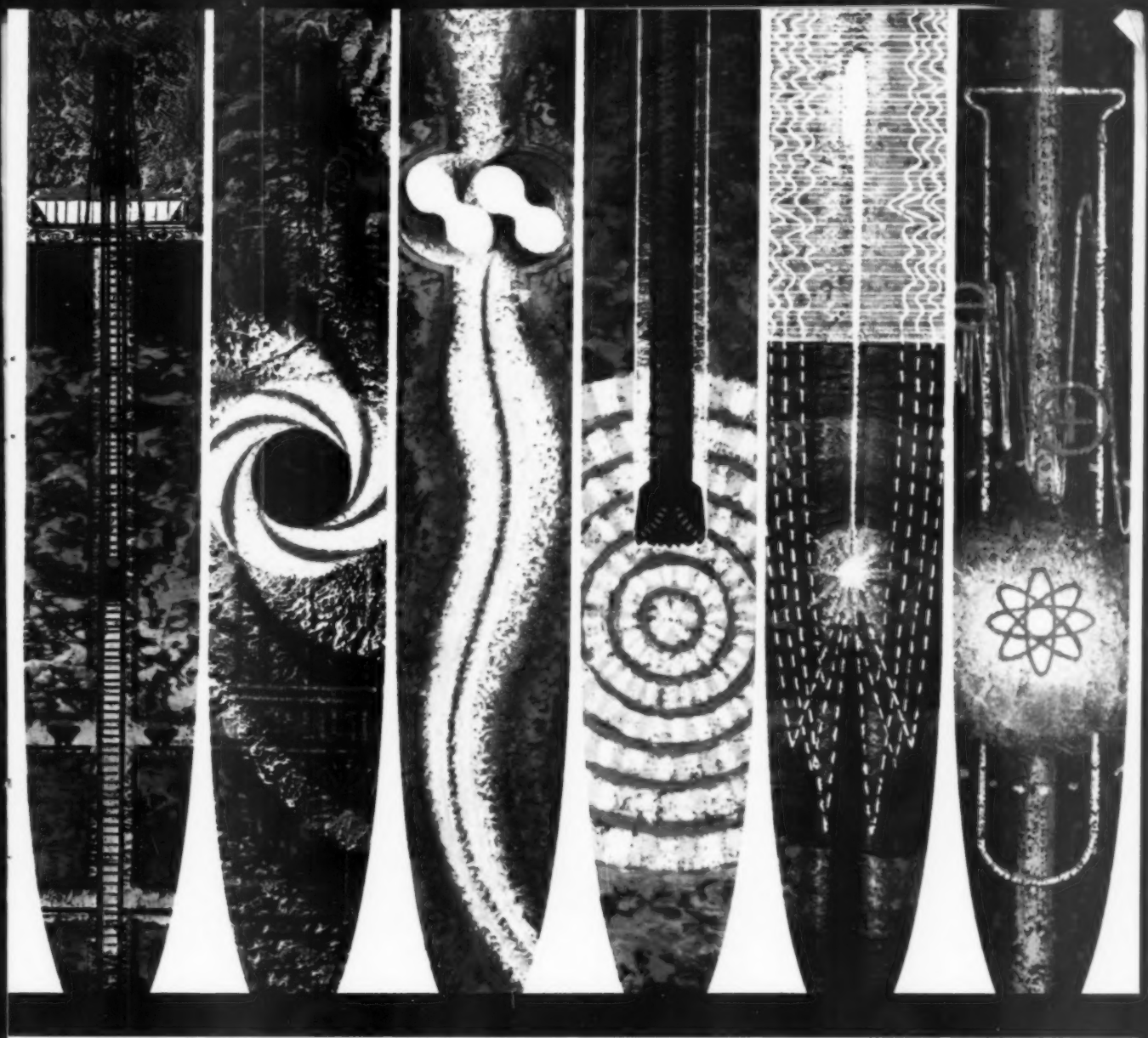
5th WORLD PETROLEUM CONGRESS

May 30 to June 5, 1959

New York City Coliseum

(Phone Western Union Convention Operator WOrth 2-7192 about Dresser men at the Congress)

YOUR DRESSER FRIENDS ARE LOOKING FORWARD TO SEEING YOU DURING THESE SHOWS!



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OIL • GAS
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It has always been in the picture

Wire rope and oil tell closely parallel stories of growth and progress; so close, in fact, that one story is incomplete without the other. Virtually from the beginning, Roebling's role in petroleum production has been significant in that we have manufactured and supplied the finest wire rope available at any given time during most of the first fantastic hundred years of oil.

Look at the amazing strides. Sixty-nine ft hole in 1859! 25,000 ft in 1959!

1859 1959

OIL'S FIRST CENTURY
-BORN IN FREEDOM
WORKING FOR PROGRESS

And Roebling is right in step. Today, it is Roebling Royal Blue Wire Rope, the strongest, toughest rope ever produced. Made from Type 1105, extra high-strength improved plow steel rope wire, Royal Blue *delivers* on the job. Its extra resistance to abrasion, shock, impact, crushing and fatigue combine to give it a 15% higher catalog strength than standard wire rope.

As for the next hundred years? Well, whatever the Trade Name of the Roebling rope being used, you can be sure that it will be the best rope *for the job.*

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Branch Offices in Principal Cities
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FOR FURTHER INFORMATION ON
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

1958 Revises Industry's Pattern

Because earnings declined, company organizations went all out for "Operation Efficiency" and for the first time in a decade there is a chance to break the down trend of the profit-sales ratio, which fell to new low last year . . . Gains for first quarter earnings outstrip volume increase. Capital outlays, delayed in 1958, are working back to 1957 peak. Estimates point to 8 percent rise this year . . .

Interest in foreign operations continues despite set-backs, shifting world conditions, and higher taxes . . . Domestic regulations and taxes expand faster than those outside U. S., influencing decisions on foreign operations and mergers.

Ernestine Adams

IN 1958 the petroleum industry took on a streamlining job and now looks to results of more efficient operations in 1959.

Annual reports of 75 companies show that 1958 was a fact-facing ordeal. It closed with profits down 21 percent from 1957 and revenues off 3 percent.

The Suez Canal episode was still with us like a vicious old-man-of-the-sea. Over-supply set tight on weighted shoulders. It slowed circulation and spread irritation.

In its annual report American Petrofina recalls that product prices and competitive practices, disregarding cost factors, deteriorated to destructive levels. "Over-production of crude oil, unrestricted product imports, surplus inventory accumulations in consequence of excess refinery runs, and a reduction in demand aggravated by an economic recession created a chaotic situation."

Sinclair's report stated that "Since the petroleum industry came of age there has never been a time when it was not confronted with problems urgently demanding solution. Its current family of problems stemming to a considerable extent from political situations at home and abroad appear more numerous and complex than usual."

Miss Adams is Management Editor.

The message goes on to name the political hazards: "Percentage depletion allowance, oil imports, investigations by government agencies that seem to be contradictory in their purposes, the retroactive increase in income tax rates in Venezuela."

Republic Natural Gas Company pointed out in its report that the over supply all but eliminated the justified but much publicized price increase of January, 1957. No noticeable decreases in cost of production have accompained the crude price reduction, added Republic.

Carter Oil Company, one of the few that increased its profiits over 1957, reminded readers, "The profits are largely due to the sale of lower cost crude oil found years ago. The increasing difficulty of finding reserves, coupled with the generally upward trend in all costs, has raised the cost of finding, developing and producing to the point where there is little, if any, profit at today's crude prices in reserves found courrently. This is true for the domestic industry as a whole."

Going back to the time of the reopening of the Suez Canal in 1957, Cities Service describes the situation this way: "The overseas demand for American oil stopped abruptly. Many domestic petroleum companies failed to adjust their operations accordingly. Inventories piled up. Excess supplies were dumped at distressed prices. Local price wars flared up over wide areas. Cut-throat competitive practices were the order of the day."

Prices Slide

Of course the main symptom of oversupply was the slump in the industry's earnings. Cut down as they did on the number of producing days in this country and on imports by the voluntary import allocation, there was still too much for the demand. Sun explains how its revenue was affected:

"For example, gasoline prices in Sun's marketing territory averaged one cent a gallon less last year than in 1957. Allowable production days in Texas last year totaled 122, compared with 171 in 1957 and 190 in 1956. Those two facts, it is estimated, depressed Company revenue last year by approximately $30,000,000."

U. S. companies involved were affected by foreign operations also. As Anderson-Prichard explained:

"Another factor contributing to the decline in earnings for the year 1958 was less income from a net profits interest in the National Iranian Oil Consortium. For the year 1957 income amounting to $625,000 was reported. Last year's report stated that additional capital expenditures were scheduled to be made during 1958 and these would have to be recovered before the

What Happened to Prices

Sinclair Oil presents this dramatic chart in its report on price trends.

company could expect to receive any additional funds. The anticipated expenditures were made, but by the end of the year had been fully recovered and the company realized $197,000 during 1958."

Continental Oil Company which had an increase in profits over 1957, explained its good fortune this way:

"The primary factors contributing to the improvement in earnings in 1958 were a 2.2% increase in crude oil production, significant reductions in overhead and operating expenses, and a decrease of $17.1 million in intangible drilling costs, which Continental charges against current earnings. Intangible drilling costs amounted to $33.9 million in 1958 and to $51.0 million in 1957."

Increases in Conoco's crude oil production were from non-prorated states.

Prices bothered the Louisiana Land and Exploration Company. Although the company produced more oil than in 1957, average price per barrel received during 1958 was $3.28, compared with $3.33 received during 1957. In August, 1958, a reduction in crude prices dropped the average down to about $3.21 per barrel.

Influence of Imports

As Ashland Oil and Refining said in its annual report, "The allocation of import quotas of crude oil is the most controversial subject affecting the oil industry today. So long as there was substantial price parity between foreign and domestic crude oil, the refiners of domestic oil were affected only indirectly, but now that foreign crude oil has become generally available in both world and domestic markets at prices which are substantially lower than domestic oil, the allocation of import quotas has become an allocation of refining profits and thus an allocation of domestic markets."

Tidewater suffered drastically from import restrictions. With almost the same revenue as in 1957 (only 7 per cent less) profits dropped from about $35.0 million to $2.6 million. Said its annual report, "Tidewater has suffered severe economic penalties under the government's program to restrict imports of petroleum into the United States. This has affected the company in several ways. The most obvious effect of the forced cutback in Tidewater's crude oil imports was that high priced domestic crudes had to be purchased and substituted for lower-priced crudes formerly imported to the Delaware Refinery. In addition, the refinery was placed in the position of not being permitted to utilize fully the special facilities designed for processing low grade crudes."

On the other side, such companies as Woodley Petroleum regretted that allowables of North American producers continue to decline to make place for increased imports. "Obviously the soundness of the economic structure of oil-producing companies in both the United States and Canada depends directly upon import control by the Federal Government," read its report. This was written before mandatory controls were announced.

Woodley management went on to say "It is not unimportant to consider these sources from a standpoint of their dependability in the long range, and especially in the event of war. Some of these sources will be available to us in the event of war and others will not."

Universal Consolidated blamed reductions in crude oil prices on the continued importation of foreign oil and products. However, the company was hopeful that governmental action will tend to restore California crudes to a realistic price structure. "Your company still has shut in approximately 600 bbl per day of low gravity crude oil due to lack of adequate market," Universal told shareholders.

Jersey Standard was exercised over the reduction of heavy fuel oil imports. Read its report:

"Our government recently imposed mandatory controls upon imports of crude oil and petroleum products into the United States. The basis of allocation for crude oil and finished oils will reduce the amounts imported by Jersey affiliates. The allocation method is, in our estimation, seriously inequitable. The inclusion of heavy fuel oil under the control system is particularly regrettable. Heavy fuel oil is widely used as a source of power in industry and electric generating stations and for heating large buildings. Because of the cost factors involved, not enough of it is made by domestic refineries to meet domestic demand, and imports have long served to provide the balance required. Reduction in the availability of heavy fuel oil would leave many consumers with no choice except to curtail activities or to turn to higher-cost sources for heat and power."

Only Bishop Oil Company mentioned the hint of price control. Said that firm's report "Partial remedy of the situation is promised by the President's mandatory order to restrict the imports which have been discouraging exploration and development by driving prices down. The order also restricts 'unnecessary' increases in the price of crude oil, permitting supplementary imports if a marked rise in price should occur."

Foreign Operations

In Table 3 of oil and gas operations we have an asterisk before the company's name if that company has foreign relations. By going down the left side you can see the great majority of the companies on our list operate abroad as well as in the United States. This includes small companies as well as large ones. Kendall Refining Company, for instance, states in its report that the Peruvian company in which they have about 10 percent interest maintains production at the level of about 2000 bbl per day. The addition of another tow boat and barges is ex-

pected to allow more oil to be produced and sold in 1959.

White Eagle report says "It seems clear that foreign oil will remain a significant part of the U. S. supply and that foreign oil markets are growing at a more rapid rate than the domestic market." Therefore, the company's principal areas have been designed to capitalize upon the search for foreign oil, as well as to maintain domestic production through methods which avoid many of the accelerating costs and risks of exploration.

Kerr-McGee Oil Industries stated "Income from foreign drilling contracts became an important revenue source, offsetting to some extent the decreased revenue from domestic drilling."

One of the companies that has been outstanding in foreign operations is Signal Oil and Gas Company. The merger with Hancock Oil in 1958 brought Signal's ownership of American Independent Oil Company up to 30.16 percent. This company (Aminoil) operates in the Kuwait-Saudi Arabia neutral zone. Signal is also in the Iranian Oil Consortium, and in Venezuela, Guatemala, Boliva, and Argentina.

One of the small companies to become interested in foreign operations is Blackwell Oil and Gas Company. It has one concession in Bolivia acquired in 1958 and the report states "We are continuing to investigate other appropriate foreign areas."

Two former domestic companies have recently begun operations outside the United States. Plymouth Oil Company's report goes into its reasons:

"This policy was initiated and implemented to make the Company more competitive, afford it a share of growing world markets, and partially alleviate the effects of restraints on our production in Texas and other major producing areas of the United States.

"In 1956, 94% of the Company's crude oil production came from Texas. In 1957, this figure declined to 91%. In 1958, as the program became progressively more of a reality, only 84% of crude production came from Texas. In January of this year, the figure was down to 79%.

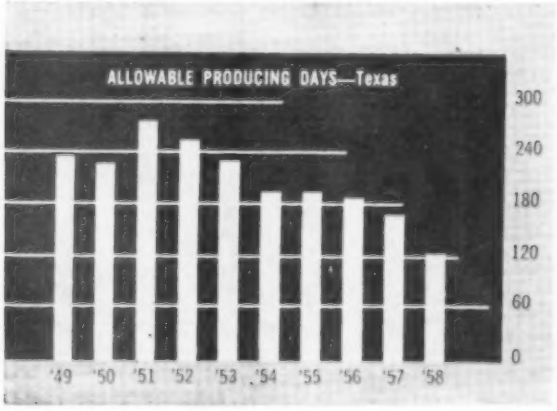
"The need to seek reserves in Canada and elsewhere outside the United States is reflected in the fact that in 1958 the number of allowable producing days in Texas was only 122."

Standard Oil (Indiana) said its venture into foreign areas was "motivated by still another consideration. As our business grows, the need for our own production becomes ever more important. Currently our Company's requirements for crude oil substantially exceed our own production. In the long range we believe it is essential for our Company to own or control the major part of its crude sources so that it will not be dependent on competitors for raw material.

"Our aim is to make our Company more profitable, and we believe that foreign operations will help to do that – not this year, nor next, but within the reasonable future."

A little longer in foreign operations, Ohio Oil Company this year reported "It was over ten years ago that the decision was made to venture into foreign lands, in the search for oil reserves. Our first production in Canada was obtained in 1949 and it has been growing steadily. During the past few years we have been accelerating our exploration in other foreign countries, and we have been encouraged for the first time by discoveries in Libya and Venezuela."

Argentina operations were mentioned in several annual reports for the first time. Union Oil Company of California explained its agreement with that country's government in which it is to take on an oil exploratory contract.



General Crude Oil Company presented graphically the "corrective action taken by the Texas Railroad Commission."

Billion $ Companies

Eight companies in the petroleum industry have a net worth — or stockholders equity — of more than one billion dollars. Here they are:

Company	Net Worth
1. Jersey Stan.	$6,547,000,000
2. Socony Mobil	$2,445,106,000
3. Gulf Oil	$2,441,297,000
4. Texaco	$2,283,742,000
5. Standard Ind.	$2,076,856,000
6. Standard Cal.	$1,990,210,000
7. Phillips	$1,515,498,000
8. Shell	$1,239,779,000

"Under this agreement Union has contracted to explore and develop two areas, totaling four million acres, in a previously undeveloped section of the oil producing Comodoro Rivadavia Basin. Initially, we will spend $5 million within five years for exploration. The maximum term of the contract is 27 years. The agreement provides that Argentina will buy all the oil produced, at prices related to world markets. Union will have the option to repurchase production in excess of Argentina's requirements. Active exploration was started in October, 1958."

Young Companies

Several companies organized in recent years have been added to our annual reports survey. To combat mergers, which are common in the petroleum industry, there are always new companies springing up to take the place of those that disappear so far as names are concerned.

One of these with a good showing is Coastal States Gas Producing Company, organized three years ago. This producing company had a 36 percent rise in its total revenue and a 46 percent gain in earnings in 1958 over 1957. Slightly more than 50 percent of its earnings are in gas gathering.

A five-year-old company, Aztec Oil and Gas, was able to show striking gains in revenue and net income. Also a producing company, it has built up considerable reserves in its short existence. Unlike the average company in 1958, its net oil production more than doubled over 1957. However, its net gas production dropped below both 1957 and 1956.

Another five-year-old company is Three States Natural Gas Company, which managed to show an upturn in earnings. Income is from oil and gas production.

A refining company in its sixth year is International Refineries, Inc., which is just a few miles south of the Great

TABLE 1. FINANCIAL STATISTICS OF U. S. PETROLEUM COMPANIES FOR 1958.

Company	Income—Add (000) Gross 1958	%	Net 1958	%	Taxes—Add (000) Direct 1957	Direct 1958	Excise 1958	Common stock 1000 shares:	Per common share issued: Price 12/31 1958	Equity 12/31 1958	Net income	Direct taxes	Dividends
Amerada	$ 102,782	—12	$ 22,485	—25	$ 12,392	7,557		$ 6,313	$103⅛	$ 25.68	$ 3.56	$ 0.00	$ 2.00
American Petrofina	70,901	+61	126	—92	1,008	1,418		6,977	11½	8.56	0.02	0.20	0.10s
Anderson-Prichard	69,534	— 2	3,846	—27	1,382	1,716		1,645	30⅝	36.30	2.08	1.04	1.20
Argo Oil	12,718	—10	4,921	none	1,474	1,296		2,000	39⅜	15.64	2.52	0.65	1.29
Ashland[2]	280,125	—13	10,332	—36	16,320	8,050		5,735	19	20.89	1.51	1.40	1.00
Atlantic	542,131	— 5	33,825	— 5	18,108	15,495	82,520	9,010	44⅝	55.35	3.61	1.72	2.00
Aztec Oil & Gas	4,330	+56	2,098	+109	175	183		2,394	17⅜	5.13	0.88	0.08	5%s
Bishop Oil	2,283	—10	156	—42	5	115		563	10⅝	9.60	0.28	0.20	0.20
Blackwell	1,484	— 5	102	—61	—	—		3,280		0.90	0.03		
British-American	320,657	+ 3	20,518	—36	17,894	19,169	59,525	12,119	41½	33.30	1.69	1.58	1.00
Champlin	68,265	— 2	7,309	—25[s]	1,600	800	7,921	4,126	23¼	16.41	1.70	0.19	1.00
Cities Service	1,029,626	— 3	44,891	—24	41,427	23,853		10,729	63⅜	59.24	4.18	2.22	2.40s
Clark O & R	75,393	+ 4	1,423	none					13		0.99		
Coastal States	3,069	+36	1,001	+46	95	145		1,446	19½	4.22	0.69	0.10	none
Colorado O & G	33,322	— 6	576	—80	674	733	4,812	3,067	15⅞	11.45	0.00[12]	0.24	none
Continental	671,470	— 2	47,465	+ 2	19,619	22,927	69,432	19,663	63⅛	19.69	2.41	1.17	1.60
Cosden	91,634	+27	5,193	—14	5,302	9,427		2,584	18⅝	13.61	2.01	3.65	1.00
Delhi-Taylor	67,759	— 3	(1,602)		1,171	1,161	5,803	5,317	14½		(0.30)	0.31	none
Douglas Oil[9]	28,448	—1	67	—88	455	178	6,063	1,151	6¾	5.14	(0.03)	0.15	none
Drilling & Exp.	9,858	—21	755	—38	115	50		1,896	11¼	8.83	0.40	0.02	0.25
Eason	4,068	none	513	—32	131	140		363	13	18.84	1.41	0.38	0.50
Fifteen Oil	2,544	—11	182	—83	210	204		1,294	11	5.88	0.14	0.16	0.30
Frontier Refining	29,434	+ 2	776	—24				1,050		8.36	0.71		0.25s
General American[2]	24,582	— 6	7,100	—22	1,686	1,688		3,048	35⅝	23.93	2.33	0.55	0.35s
General Crude	11,876	—14	2,861	— 8	1,155	1,161		1,848	29⅜	18.69	1.55	0.63	1.00
Getty Oil	33,422	none	12,873	—12	4,500	3,271	—	16,004	27¼	8.89	0.79	0.20	none
Gulf Oil	2,769,377	+ 1	329,533	— 7	206,658	209,111	428,736	32,390	126	75.37	10.17	6.46	2.50s
Honolulu	40,762	—11	11,845	—19	6,044	4,877		3,751	66½	23.09	3.16	1.30	2.00
Hugoton	6,427	— 3	3,008	— 3	1,749	1,742		851	78	128.17	3.54	2.05	2.65
Husky Oil[2]	29,405	+ 3	1,397	—41	507	550		3,071	9	4.56	0.36	0.18	none
International Ref.[2]	15,947		433			335		2,400	4⅜	1.77			
Intex Oil	2,929	— 7	771	— 3	160	176		929	10⅞	5.31	0.97	0.22	none
Kendall Refining	20,012	— 7	755	— 7	1,162	1,069	2,891	397	22	34.53	1.90	2.69	1.10
Kerr-McGee[2]	137,649	+26	5,379	—14	3,002	1,457	28,196	2,379	54¼	31.57	1.94	0.61	0.80
Leonard Refineries[9]	58,658	+ 1	2,021	—19	2,438	2,587	5,938	1,120	13¾	14.57	1.81	2.31	0.80
La. Land & Expl.	32,855	— 7	17,367	—10	12,255	10,479		8,966	56⅛	3.77	1.94	1.16	1.50
Midwest Oil	19,452	+ 1	7,269	+ 8	2,666	2,696		2,524	38	14.94	2.88	1.07	1.76
Monterey[5]	21,886	— 7	2,478	+91	1,187	1,200		1,806	36⅛	28.99	1.37	0.66	none
Murphy Corp.[7]	28,585	+40	2,758	none	1,188			2,363	26	18.21	1.17		none
Nortex O & G	1,943	—33	(360)					545	6	2.46			none
Ohio Oil	274,401	— 6	32,156	—22	22,281	12,830	33,280	13,127	39⅞	27.97	2.45	0.98	1.60
Phillips	1,072,867	— 6	84,237	—12	62,904	45,546	116,000	34,353	48¼	44.12	2.45	1.33	1.70
Plymouth	86,250	—27	4,588	—24	2,726	680	16,368	2,560	28¾	22.21	1.79	0.27	1.20s
Pure Oil	478,296	— 7	28,822	—19	19,210	7,783[1]	106,887	8,602	44¾	44.11	3.34	0.90	1.60
Quaker State	49,955	— 2	1,892	— 5	2,586	3,031	5,603	927	25⅞	27.44	2.29	3.67	1.60
Republic[2]	16,328	— 7	3,101	—29				2,998	33⅛	11.76	1.09		0.80
Richfield	258,208	+ 1	20,094	—29	18,163	14,756	67,236	4,020	100⅝	57.42	5.02	3.67	3.50
Shamrock[10]	56,483	+ 2	9,052	+ 3	2,550	2,588	7,400	3,459	43¾	14.24	2.62	0.75	1.60
Shell Oil	1,674,132	— 6	116,563	—14	89,662	66,214	287,765	30,287	85¼	43.89	3.85	2.19	2.00
Signal O & G	148,871	+ 3	17,483	—17	9,240	7,182	17,435	8,670	44	20.04	1.99	0.83	0.80s
Sinclair	1,201,721	— 5	49,473	—38	71,918	59,912	226,309	15,315	65¾	63.08	3.23	3.91	3.00
Skelly Oil	255,661	— 4	27,687	—25	18,507	13,478	27,593	5,746	66¾	59.60	4.81	2.35	1.80
Socony Mobil	2,932,794	— 3	156,786	—29	141,664	143,018	320,000	48,433	48⅜	50.48	3.24	2.95	2.00
South Penn	53,144	— 8	3,031	—49	4,159	2,788	5,224	1,580	37	31.17	1.92	1.76	2.25
Southland Royalty	9,693	—12	3,781	—11	1,728	1,750		833	83½	28.97	4.54	2.10	3.00
Standard Calif.	1,688,527	— 3	257,759	—11	97,804	98,437	213,922	63,224	59¾	31.48	4.08	1.56	2.00
Standard Ind.	1,882,441	— 7	117,775	—22	85,668	64,746	368,861	35,769	47¼	58.06	3.29	1.81	1.69
Standard N. J.	7,712,257	— 3	562,475	—30	814,800[11]	805,700[11]	548,600	214,890	57⅝	30.47	2.72	8.41	2.25
Standard Ohio	358,000	— 5	24,044	+ 1	16,616	15,851	77,416	4,832	59¾	51.45	4.82	3.27	2.50
Sun Oil	724,032	— 7	32,061	—33	35,628	19,512	167,972	11,739	63⅛	46.90	2.73	1.66	1.00s
Sunray Mid-Con.	372,285	— 5	40,664	—29	34,123	20,663	41,418	17,369	27⅝	24.93	2.14	1.19	1.32
Sunset International	13,271		407					4,423	4½	2.70	0.09		0.08
Superior[5]	111,372	+ 1	16,551	—12	9,370	8,662		422	1755	322.34	39.20	20.51	none
Texas Co.	2,475,630	+ 1	310,168	— 7	153,745	116,210	436,909	58,388	85¾	39.11	5.31	1.99	2.35
Texas Gulf	18,466	—12	3,973	—42	2,490	2,273		4,030	32⅜	10.48	0.98	0.56	0.60
Texas Pac. C & O	23,592	— 5	6,231	—14	2,431	1,856		3,876	38¾	18.82	1.67	0.48	1.00
Three States N. Gas	4,493	— 9	587	+12				6,500	5½	2.00	0.09		none
Tidewater	552,944	— 7	2,616	—93	11,731	15,747	100,929	13,225	24⅞	29.25	(0.03)	1.19	5%s
TXL Corp.[10]	11,695	+ 1	3,746	—14	1,537	1,085		5,574	22⅝	5.06	0.67	0.19	none
Union Calif.	412,592	— 6	24,999	—35	18,356	16,703	79,917	7,872	46¼	54.11	3.18	2.12	1.35s
Union O & G, La.	34,854	+ 5	8,141	+20	65	231		1,827	85¼	22.82	4.46	1.26	0.80
Universal Consol.	8,572	— 3	2,773	—22	1,418	1,321		959	51	12.96	2.89	1.38	2.60
White Eagle[6]	13,533	+17	(445)		70	75		1,762	8⅜	4.66	(0.25)	0.04	5%s
Wilcox Oil	7,658	— 9	910	+ 2	234	238		305	44	32.69	2.99	0.78	1.00s
Woodley Pet.	7,916	+ 5	3,094	— 6	355	368		820	67¼	22.38	3.77	0.45	0.50s
TOTALS	$31,780,536	—3	$2,591,704	—21	$2,139,653	$1,920,793	$3,974,881	—	$4615⅝	—	$196.27	$112.06	$80.04

s — Plus stock dividend.
( ) — Loss.
‡Not including payroll taxes.
‡Issued 1958.
[1]% change from 1957.
[2]Year ends June 30.
[3]Year ends May 31.
[4]Income refund of $4,627,000 from loss carry back.
[5]Year ends August 31.
[6]Year ends September 30.
[7]Year ends April 30.
[8]Inc. capital gains of $1.4 million in 1957.
[9]Year ends March 31, 1958 and 1959.
[10]Year ends November 30.
[11]Not including import duties of approx. $1 billion each year.
[12]Preferred stock dividends deducted.

TABLE 2. CAPITAL ASSETS, CAPITAL EXPENDITURES, AND CHARGE-OFFS.

Company	Years in business	At end of fiscal 1958					Depreciation depletion, amortization[3] $1000	Capital and exploration expenditures[4] $1000		
		Gross fixed assets $1000	Net fixed assets $1000	Working capital $1000	Long term debt $1000	Stockhldrs equity[2] $1000		1957	1958	1959 est.
Amerada Petroleum	38	438,804	100,831	54,376	none	162,118	13,155	51,025	46,325	46,000
American Petrofina	3	97,144	69,877	12,023	25,026	59,719	6,121	37,762[5]	32,198[5]	—
Anderson-Prichard	37	111,241	61,969	15,582	20,600	59,710	5,819	15,148	10,625	11,000
Argo Oil Corp.	22	49,771	25,038	2,634	none	31,280	1,719	5,546	4,171	—
Ashland Oil & Refining Co.	35	216,623	87,743	55,539	34,840	119,803	14,992	22,522	14,310	15,371
Atlantic Refining Co.	88	1,030,597	573,853	83,624	180,300	498,727	46,315	120,294	82,010	86,971
Aztec Oil & Gas Co.	5	22,797	18,152	568	5,175	12,283	2,561	1,813	3,033	4,000
Bishop Oil Co.	32	12,668	6,625	(40)	1,181	5,404	759	941	528	—
Blackwell Oil & Gas	54	9,475	2,490	467	none	2,957	610	—	569	—
British American	52	515,396	319,850	114,717	56,803	403,524	31,847	94,894	81,474	—
Champlin Oil & Refining	30	119,901	81,134	18,374	34,495	67,696	9,673	17,495	13,429	18,525
Cities Service Co.	49	1,379,787	779,690	310,231	460,104	635,576	82,626	179,283	150,703	—
Coastal States Gas	3	16,669	12,380	1,093	8,148	6,097	695	—	—	—
Colorado Oil & Gas	7	90,856	67,939	9,439	24,313	35,119	3,876	7,500	10,830	6,650
Continental Oil Co.	84	1,231,248	619,662	120,958	147,193	387,137	64,902	141,933	78,773	104,000
Cosden Petroleum	22	64,420	42,874	7,061	14,592	35,161	4,144	16,765	13,314	—
Delhi-Taylor Oil	13	71,367	42,616	5,324	45,208	4,232	3,878	15,990	4,000	1,500
Douglas Oil of Calif.	12	16,937	6,285	2,000	1,546	7,764	1,180	1,000	1,913	1,310
Drilling & Exploration	30	29,583	13,233	3,414	650	15,997	2,142	5,725	—	—
Eason Oil Co.	45	12,805	6,370	207	65	6,846	662	—	1,015	1,500
Fifteen Oil Co.	21	9,791	6,292	1,316	none	7,608	549	1,291	988	1,669
Frontier Refining Co.	—	20,940	12,292	928	4,440	8,777	—	2,261	2,805	—
General American Oil	22	126,857	60,382	3,857	541	72,921	8,026	13,511	—	—
General Crude Oil Co.	29	45,436	24,490	10,040	none	34,530	1,559	7,500	5,099	6,300
Getty Oil	30	124,727	73,028	14,371	44,867	142,278	5,198	—	—	—
Gulf Oil Corp.	58	4,183,057	2,057,164	565,498	300,785	2,441,297	261,165	664,217	510,492	—
Honolulu	49	141,832	66,414	19,501	629	86,628	7,056	14,847	10,870	14,000
Hugoton Producing Co.	9	9,477	7,555	3,353	none	10,908	—	281	340	650
Husky Oil Co.	20	28,648	17,634	9,039	13,832	13,996	1,804	2,678	3,673	3,250
International Refining	5	9,732	7,238	1,967	3,000	4,238	—	—	—	—
Intex Oil Co.	19	11,911	5,541	584	1,238	4,936	6,369	—	1,003	1,233
Kendall Refining Co.	77	24,228	7,913	5,485	295	13,724	845	—	891	—
Kerr-McGee Industries	27	127,040	91,950	34,718	60,708	75,099	8,776	19,710	34,657	32,885
Leonard Refineries	23	39,840	31,505	8,281	5,506	—	1,503	1,885	3,267	3,000
Louisiana Ld. & Exploration	33	34,957	25,054	8,726	none	33,780	2,001	5,446	5,205	—
Midwest Oil Corp.	47	83,894	31,593	5,834	none	37,713	2,674	6,194	6,245	7,337
Monterey Oil Co.	8	117,151	84,861	5,633	36,000	52,377	8,042	8,184	12,013	7,538
Murphy Corp.	8	77,313	58,684	8,932	24,586	43,030	4,526	17,293	17,100	—
Nortex Oil & Gas Co.	5	6,749	3,540	(69)	2,134	1,337	663	—	—	—
Ohio Oil Co.	71	625,711	274,462	78,382	none	367,165	24,926	64,799	39,241	40,036
Phillips Petroleum	41	1,893,709	1,097,416	217,148	302,276	1,515,498	127,708	216,417	132,818	135,000
Plymouth Oil Co.	35	119,134	58,589	16,433	18,971	56,856	5,230	10,101	9,733	7,076
Pure Oil Co.	45	677,406	341,909	119,327	86,383	379,436	29,959	67,561	57,360	—
Quaker State Oil Refining	28	32,079	11,655	10,722	650	25,436	1,853	1,796	999	—
Republic Natural Gas Co.	24	61,394	35,496	5,760	6,500	35,256	4,104	4,841	3,727	—
Richfield Oil Corp.	47	470,587	230,796	124,806	143,588	230,836	26,477	59,231	47,122	—
Shamrock Oil & Gas	30	104,339	69,174	7,516	28,290	49,266	4,993	16,373	12,827	11,800
Shell Oil Co.	46	2,516,309	981,860	299,738	143,342	1,239,779	206,585	265,635	233,082	250,000
Signal Oil & Gas Co.	36	250,466	133,915	34,335	14,572	173,744	13,254	26,700	24,600	25,700
Sinclair Oil Corp.	43	1,695,643	927,008	296,042	353,653	966,149	89,456	157,000	131,000	—
Skelly Oil Co.	39	380,080	342,489	57,104	3,888	342,489	35,768	55,647	62,872	—
Socony Mobil	76	3,455,110	1,784,570	661,766	176,660	2,445,106	207,811	420,804	398,000	420,000
South Penn Oil Co.	69	125,347	21,828	25,225	none	49,255	3,925	5,382	4,927	—
Southland Royalty Co.	2	29,944	18,156	5,982	none	24,139	2,485	—	1,559	1,732
Standard Oil Calif.	80	2,992,170	1,629,329	426,437	179,486	1,990,210	145,891	410,679	343,306	400,000
Standard Oil Ind.	70	3,246,916	1,872,696	580,279	458,604	2,076,856	168,693	420,658	357,974	—
Standard Oil N. J.	76	7,946,127	6,457,204	1,588,000	699,149	6,547,000	487,515	1,376,965	1,071,650	1,000,000
Standard Oil Ohio	89	486,274	261,030	62,964	66,000	248,617	24,023	69,885	40,312	48,000
Sun Oil Co.	58	841,567	447,820	133,416	38,666	550,598	56,425	132,800	100,800	124,800
Sunray Mid-Continent	39	764,920	385,057	87,767	50,453	433,065	43,562	74,898	52,459	68,000
Sunset International	—	19,852	14,367	917	4,238	11,959	1,186	—	—	—
Superior Oil Co.	38	300,071	201,165	29,161	94,213	136,113	41,133	71,519	72,465	—
Texas Co.	57	3,708,388	1,834,453	627,474	348,090	2,283,742	233,045	481,708	414,535	514,000
Texas Gulf Producing Co.	28	73,482	38,350	10,569	6,690	42,228	5,775	12,425	11,344	7,076
Texas Pacific Coal & Oil	70	104,860	62,355	10,394	none	72,946	5,866	9,186	14,218	—
Three States Natural Gas	—	25,776	19,365	1,920	8,279	13,006	1,069	—	—	—
Tidewater Oil Co.	80	1,101,589	623,309	95,317	283,855	386,862	60,358	140,231	94,053	100,000
TXL Oil Corp.	4	30,446	23,030	5,202	none	28,232	4,141	5,919	5,908	6,000
Union Oil of Calif.	68	925,986	431,657	167,332	184,069	425,896	60,601	91,346	66,392	75,470
Union Oil & Gas La.	64	91,927	48,364	7,725	14,398	41,691	4,601	18,822	15,800	—
Universal Consolidated	37	13,273	4,893	7,541	none	12,433	2,753	800	2,125	2,000
White Eagle Oil Co.	39	33,453	16,932	1,469	11,003	8,204	2,787	6,287	4,701	4,550
Wilcox Oil Co.	41	20,005	10,339	3,122	none	9,957	493	1,263	1,144	1,200
Woodley Petroleum	36	27,593	17,883	2,949	6,975	18,355	1,159	2,650	3,371	—
TOTALS	—	$45,961,986	$26,346,128	$7,336,468	$5,295,552	$28,883,564	$2,756,502	$6,203,465	$4,997,259	$3,610,053

[1]Fiscal years given in Table 1 footnotes.
[2]Other assets included here in this statement of net worth.
[3]Last fiscal year only.
[4]Exploration expenditures here are mostly dry hole costs and new property. Some companies include exploration expenses such as seismic crews.
[5]Major part property acquisitions.

Lakes port of Duluth, Minnesota. When the company was organized the site was chosen for its marketing location in Northern Minnesota and Wisconsin and because of new business expected from the St. Lawrence Seaway project. Duluth is the western terminus of the great waterway.

Financial Operations

Although profits dropped 21 percent from 1957, in many ways last year was a year of growth.

Net fixed assets (property and facilities) increased by 8.5 percent, reaching $26,346,128,000 ($26 billion) for 75 companies in the survey. (Table 2). Working capital expanded 4.6 percent, almost offsetting the rise in long term debt of some $400 million for the group.

Stockholders' equity increased about 3.5 percent, bringing the 75 companies to a total net worth of almost $29 billion.

This shows a further decrease in rate of return on net worth. Here are the last nine years — the first five from Petroleum Facts and Figures* and the last four from our survey.

Rate of return on net capital employed

1950	15.5%
1951	16.8%
1952	14.6%
1953	14.5%
1954	13.0%
1955	13.0%
1956	12.7%
1957	11.8%
1958	9.0%

Sohio suggest that instead of rate of return on net book value, a more meaningful measure of performance is rate of return on borrowed and invested capital "due to the leverage effect of earnings derived from use in the business of funds obtained from senior capital or borrowings."

Using this base (stockholders' equity plus long term loans) the rate of return on all capital employed was

10.0% in	1957
7.6% in	1958

The rate last year is getting close to utility margins and makes little or no allowance for a competitive, uncertain resource industry.

Profit on revenues also saw a big step-down this year. Percentage of earnings to revenues for the last four years are:

1955	10.7%
1956	10.7%
1957	10.0%
1958	8.2%

*Published by API. These figures were compiled by Economics Department, Atlantic Refining Company.

Capital and Exploration Expenditures

By U. S. Companies Here and Abroad

(Based on estimates made by 46 petroleum companies)

	1958 estimates* on April 1, 1958	Actual 1958 spending	Estimates for 1959 outlays
Exploration (mostly dry hole costs and lease acquisition)	$2,300 million	$1,829 million	$1,840 million
Production (includes gasoline plants)	3,100 million	2,640 million	2,940 million
Transportation (does not include interstate gas transmission lines)	500 million	455 million	410 million
Manufacturing (also petrochemicals of oil companies)	1,100 million	1,041 million	1,260 million
Marketing	800 million	688 million	750 million
Other	200 million	157 million	150 million
TOTAL	$8,000 million	$6,810 million	$7,350 million

*Published in May 1958 issue of The Petroleum Engineer.

Even U. S. Steel, which also had a bad year in 1958, made 8.7 percent return on sales. Last year we made the statement that 1958 would show improved earnings because rate of return on investment had drifted so low for an industry as hazardous as ours. Several records of the year reveal this trend but the quarter reports had another story to tell. If 1958 did nothing else, it made management more than ever aware that results of indifferent practices show up in financial.

Total taxes rose again. The slight cut in direct taxes was more than offset by rises in excise taxes — and all must come from the consumer who buys industry products. This is true, too, of import duties which Jersey designates in its tax list. United States and foreign governments, through various tax levies, benefitted from the operations of Jersey and its affiliates to the extent of $2,355,200,000 in 1958, an all-time record. Such tax levies in 1958 were equivalent to $11.40 per share — more than five times the dividend payments to shareholders and more than double the employee payroll and benefit costs.

At its annual meeting a Gulf spokesman declared it was surprising how few persons realized that petroleum is one of the most heavily taxed of all industries. He said that some $638 million was turned over by Gulf in 1958 to various Federal, State and local government tax agencies. This amounted to 20 cents out of every dollar taken in by Gulf being paid out in direct taxes.

One bright note on the financial side — the combined stocks (one share each) of companies in the survey appreciated 20 percent from December 31, 1957 to the same date in 1958.

Most companies in the first quarter of 1959 showed good improvement in revenues and still better in earnings. Table at left gives some comparisons.

INCOME FOR FIRST QUARTER

(Ending March 31 —estimates)

Company	Gross ($1000) 1959	% Change from 1958	Net ($1000) 1959	% Change from 1958
Atlantic	115,309	+ 7	11,902	+342
Aztec	—	—	1,270	+532
Champlin	17,667	+12	2,224	+ 71
Coastal States[1]	819	+20	262	+ 15
Colo. O&G	10,170	+18	396	+ 20
Continental	165,416	+ 6	14,379	+ 34
Delhi-Taylor	27,578	+34	2,509	[6]
General Crude	3,330	+12	755	+ 2
Kendall Ref.[2]	5,118	+12	158	+ 23
Midwest Oil	5,005	+ 7	1,710	— 9
Monterey[3]	11,741	+ 1	1,242	— 17
Murphy[4]	11,465	+54	1,021	+223
Plymouth	27,000	+14	1,700	+ 95
Shamrock[4]	13,603	— 3	2,382	— 6
Shell	452,218	+10	34,467	+ 13
Socony Mobil	—	—	—	+ 12
Sun Oil	202,344	+21	11,227	+ 82
Sunray Mid-Con	95,550	+ 7	9,743	+ 1
Superior[5]	35,748	+37	8,813	+134
Texas Gulf	4,254	+ 2	1,219	+ 5
Texas Pacific	—	—	2,020	+ 35
Texaco	—	—	91,220	+ 30
Tidewater	—	—	8,000	+900
TXL[4]	3,369	+15	1,148	+ 22
Wilcox	2,018	—16	216	+ 14

[1]Quarter ending September 30
[2]Quarter ending January 31
[3]Six months ending February 28
[4]Quarter ending February 28
[5]Quarter ending November 30
[6]Loss of $246,000 in 1958.

Capital Expenditures

BURDENED WITH HIGH capital requirements the oil industry will increase in 1959 its expenditures for exploration and other investments. This will amount to approximately 8 percent more than was spent in 1958.

Cities Service points out the increased need for expansion: "The nation's growing energy requirements emphasize the need to maintain an atmosphere within which the petroleum industry can raise vast sums of capital for expansion. In the past decade, the petroleum industry has spent approximately $72 billion for property, plant and equipment. It is estimated that twice that amount, or $140 billion, must be expended in the next decade to keep abreast of new demands. If this tremendous requirement is to be met, it is obvious that the oil industry must have an adequate price structure and a healthy business climate."

Although capital outlays dropped sharply from 1957 there were still high expenditures to make additions to reserves and property. Some companies increased their capital expenditures. Midwest Oil Corporation spent slightly more than in 1957 and Skelly Oil Company, which made an outlay of almost $63 million in capital expenditures, exceeded anything previously spent. Former high point was $55.6 million in 1957.

It must be remembered that peak 1957 spending included the purchase of Venezuelan concessions. Several reports speak of this. Atlantic Refining pointed out that it paid $28 million for this purpose in 1957.

Superior Oil Co. explained that in 1958 its capital expenditures were being used in Venezuela: "Domestic exploration was curtailed in anticipation of large cash requirements for development in Venezuela. Intangible development expenditures in Venezuela were offset by a reduction of similar expenditures in this country. This does not mean the company has changed its long-range policy of continuing exploration for new domestic reserves."

The table shows our estimates in May, 1958, based on budget plans for the year. At that time capital and exploration outlays were estimated at $8 billion. Actual spending was about $6.8 billion.

Exploration outlays will be only slightly more in 1958, according to the estimates now made. This is about $1.8 billion and comprises mostly dry hole costs and lease acquisitions. Some companies include rentals and expenses of geological and geophysical work.

This item is the one most apt to change as the year progresses and it could rise considerably with rise in demand. Last year exploration expenses were cut more than any other part of the capital budget.

Production investments have the largest increase in store. The new automatic production equipment is probably one cause of the hike. Development drilling in expensive new offshore fields and in foreign fields may account for part of the rise.

Less transportation capital is budgeted than was spent last year. This does not include the big gas transmission lines owned by utility corporations, which have larger expansion plans.

Manufacturing — that is, refining and petrochemical plants — will have a 21 percent increase in 1959 if budgets are followed. The proposed marketing investment is 9 percent higher than last year.

This year will see some $7.6 billion expended by the U. S. oil industry to find oil and gas reserves and to build facilities for other operations in the U. S. and abroad.

Capital Expenditure Estimates

If you are puzzled by a variety of estimates of capital outlays, you are not alone. The range is so great as to make one discount the whole effort at predicting what the industry plans to do.

Some estimates are for U. S. operations only, some for free world.

Our figures are limited to expenditures by U. S. companies based on actual survey of 75 corporations. More than half the companies provide capital expenditure budgets. We do not separate U. S. and foreign expenditures, which in many cases would be our own decision as companies often divide outlays as the year progresses.

Our exploration figure is arbitrary, based on only 12 company budgets that do make this separation. Some exploration expenditures are capitalized (usually if operations are successful); some entered as current expenses (this varies).

We believe these estimated figures are conservative, considering that our list of 75 companies drilled less than one-third of the wells in the U. S. in 1958.

To give you some idea of the difficulty in assessing the value of estimates, here is one example.

This news item was published:

"The petroleum industry's capital expenditures this year will be 13 percent greater than in 1958, with oil companies spending $2.7 billion for plants and equipment, according to the Commerce Department. This total outlay compares with the all-time high of $3.5 billion in 1957."

Upon any inquiry to the U. S. Department of Commerce to find out what the estimate includes, we received this explanation:

"The plant and equipment expenditure figures represent total capital expenditures of firms classified in petroleum manufacturing. They include all charges to fixed asset accounts but exclude outlays for land and mineral rights, expenditures charged to current account and expenditures made outside continental United States.

ment of Commerce-Securities and

"Each company in the Depart-Exchange Commission survey submits a single consolidated report embracing all of its capital expenditures as defined above. The firm is given an industry classification according to its primary activity, based on its sales, following the Standard Industrial Classification. Most of the large integrated refiners are classified in petroleum manufacturing, even though they make sizable capital expenditures for well drilling, transportation, marketing, etc.

"We do not publish a figure covering all investment in the petroleum industry broadly defined. Our mining figures include, but do not show separately, expenditures of firms whose chief activity is petroleum and gas drilling; our nonrail transportation industry includes oil pipeline companies and our commercial classification includes petroleum firms engaged in the marketing of petroleum products."

From Champlin Oil and Refining Company report.

Oil and Gas Operations

Exploration vs Development

There has been some disagreement about the amount of exploration drilling in 1958 in comparison with development drilling. Annual reports show a heavier proportion for exploratory drilling than most estimates given, including that of AAPG. For instance in 1957 Humble drilled 867 wells, 19 percent of which were wildcats and field wildcats. In 1958 the percentage was 21 exploratory wells out of a total of 557 wells drilled.

In 1957 only 4.5 percent of Socony Mobil's 882 wells were wildcats. In 1958 9.4 percent of 487 wells drilled were wildcats.

Most plans point to the same trend. In 1959 Woodley Petroleum Company, for instance, stated that "we plan to drill more wildcats and appraisal wells than usual in an endeavor to find new oil reserves." TXL expects to drill a greater percentage of exploratory wells in 1959.

Fifteen Oil Company reports "during 1959 five development wells have been budgeted at a cost of $399,000 and eight wildcat wells at a cost of $1,270,000, or a total of $1,669,000. This is an increase of 70 percent over the $988,000 expended on the 1958 drilling program.'

It should be mentioned that the companies in our survey are in the minority so far as drilling is concerned. Operations of our 75 companies account for less than one-third of the drilling.

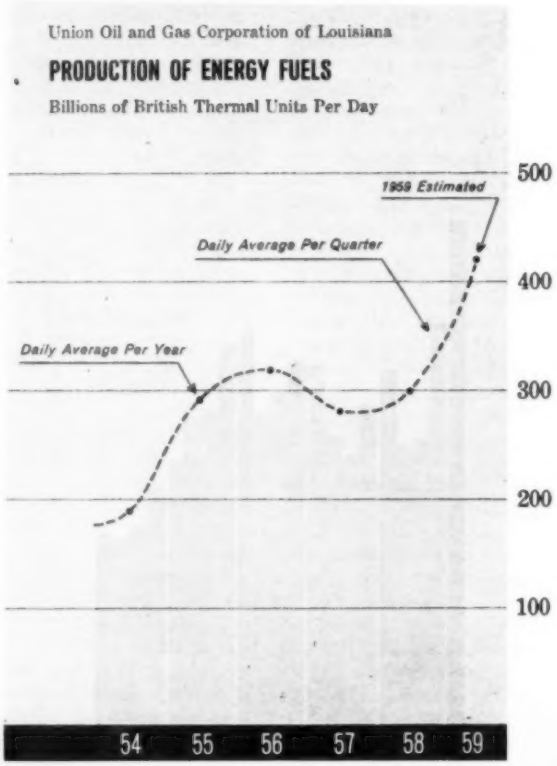
As usual the surveyed companies have a higher discovery percentage than the whole industry. There was a discovery for every 3.6 wells.

Production

A new view of production was given by Union Oil and Gas of Louisiana. Stated the report:

"In view of an increasing consciousness with respect to energy supply and demand in the United States it is of interest to note the upward trend of Union's production of energy fuels for the period 1954 to 1959 as presented on the chart below. The energy produced is measured in terms of the billions of British thermal units which are contained in the Company's combined production of crude oil, natural gas and natural gas liquids. It is seen that this production in terms of Btu's has risen from 175 billion Btu's per day in 1954 to 460 billion Btu's per day in the first two months of 1959, an increase of 163 percent. The alternating high and low points on the chart in 1956, 1957 and 1958 result from seasonal changes in demand."

A major trend in the production industry continues to be secondary recovery. Nearly every annual report



Union Oil and Gas of Louisiana gives its production of crude oil, natural gas and natural gas liquids on this graph as total energy in Btu's.

TABLE 3. OIL AND GAS OPERATIONS — 1958

Company	Net lease or fee dev. or undev., 1000 acres	Net wells drilled 1958	Net producers		Wildcats, net	Discoveries, net	Net producing wells owned	Net Production		Refineries Owned			Estimated Reserves	
			Oil	Gas				Crude oil b/d‡	LPG b/d‡	Gas MM cf/d‡	Crude oil capacity b/d‡	Crude runs b/d‡	Oil[15] million bbl.	Gas, billion cu ft
*Amerada	—	226	—	—	—	—	3,558	79,870	—	—	none	—	750	2500
*American Petrofina	595[1]	28	12	—	13	4	1,031	9,342	—	38	50,000	38,250	31	230
*Anderson-Prichard	708	73	49	3	15	4	1,114	13,001	—	40	37,500	30,228	—	—
Argo Oil	981[1]	—	—	—	—	—	—	12,084	—	—	none	—	82	205
*Ashland O & R	461[1]	44	18	3	21	4	2,579	8,139	—	—	166,500	134,750	61.5	—
*Atlantic Ref	10,015	267	175	29	52	17	4,727	119,298	—	527	210,000[1]	191,084	722	3647
Aztec O & G	187[1]	32	23	9	—	—	296	2,803	—	36[†]	none	—	19	798
*Bishop Oil	78,866	—	—	—	—	—	315	2,315	—	—	none	—	—	—
*Blackwell	—	—	—	—	—	—	—	1,226	—	3	none	—	—	—
*British-American	16,500	201	94	11	85	11	—	60,164	—	93	165,000	114,120	430	3650
*Champlin	1267[2]	81	44	17	—	—	—	13,962	8,416	299	30,000	25,155	51	1426
*Cities Service	6,586[3]	441[4]	352	45	83	24	—	117,106	—	656	313,000	252,000	—	—
*Coastal States	74,065	18	2	11	8	4	117	521	137	17	none	—	8	376
*Colorado O & G	1,259	45	33	6	8	4	838	6,589	—	45	20,000	15,966	—	—
*Continental	37,388[5]	413	310	21	55	16	7,546	136,547	12,019	385	154,200	148,768	—	—
Cosden	174[1]	51	39	—	—	—	468	5,122	—	9	50,000	38,436	28	29
*Delhi-Taylor	28,259	14	9	3	3	1	—	5,217	—	74	55,000	30,000	48	3026
*Douglas Oil	9,900	14	14	—	—	—	91	1,730	—	416	21,500	16,367	7	—
*Drilling & Exp.	—	32	16	2	14	2	460	3,240	170	8	none	—	—	—
Eason	128[1]	10	8	—	6	2	250	1,720	—	7	none	—	6	51
Fifteen Oil	79[1]	8	6	—	—	—	99	1,942	—	4	none	—	—	—
*Frontier Ref	244	14	10	1	—	—	—	1,400	—	—	20,000	17,000	—	—
*General American	872	37[6]	29	—	7	1	2,923	24,816	—	—	none	—	111	250
General Crude	1,170[1]	47	10	2	31	6	323[6]	8,930	—	16[†]	none	—	—	—
*Gulf Oil	107,274	1,775	1,377	66	218	55	18,118	1,297,414	108,652	874[1]	555,877[1]	485,034[1,7]	—	—
Honolulu	14,847	68	50	4	15	2	1,505	31,295	2,891	61	none	—	—	—
Hugoton	131[1]	3	—	3	—	—	159	—	1,180	95	none	—	—	1
*Husky Oil	364	8	6	1	3	1	158	5,256	900	6[†]	6,500	5,365	39	38
Intex Oil	145[1]	24	10	1	15	2	133	2,863	—	32	none	—	12	1
*Kendall Ref	—	35	22	—	—	—	2,176	1,124	—	80	4,800	3,750	—	—
*Kerr-McGee	1,640	28	7	10	12	2	624	5,109	3,789	120	40,500	37,471	17	903
Leonard Ref	—	—	—	—	—	—	—	—	—	—	29,000	24,601	—	—
La. Land & Exp	725[1]	16	13	1	1	0	96[6]	20,611	—	42	none	—	120	1
*Midwest Oil	837	51	31	—	19	6	909	16,418	—	40	none	—	—	—
Monterey	494	24	20	—	5	1	674	13,981	6,466	8	none	—	60	52
*Murphy	1,738	66	43	4	15	4	387	10,120	—	44	13,500	—	48	2
Nortex O & G	24	3	1	1	—	—	181	1,000	—	8	—	—	8	—
*Ohio Oil	36,700	273[13]	199	12	49	9	8,137	90,059	10,622	289	50,000	41,425	657[11]	2265[11]
*Phillips	21,193[8]	271[1]	175	51	15	6	8,353[1]	144,300	91,600	2610	266,500[1]	218,000[1]	1,400	17,700
*Plymouth	803	57	55	2	10	2	1,016	15,710	222	83[†]	45,000	26,700	—	—
*Pure Oil	10,783	122[11]	67	10	31	10	5,444[1]	59,535	4,265	284	183,800	164,632	460	3750
Quaker State	—	—	—	—	—	—	—	1,585	—	—	—	7,729	—	—
Republic	—	39	13	8	—	—	1,072[4]	8,335	—	163	none	—	—	—
*Richfield	5,056[11]	104	50	3	46	5	1,384	62,033	—	—	173,700	119,044	281[11]	627[1]
Shamrock	675	122	77	21	47	25	1,066	4,998	—	201	25,000	19,700	85	1700
*Shell	12,195	950[4]	623	110	166	—	16,382	302,000	32,300	864	584,000	464,000	1,500	6700
*Signal	2,250	79	63	3	16	4	1,004	57,200	5,800	37	—	18,800	—	—
*Sinclair	9,684[11]	347	223	40	67	14	—	187,408	—	381	499,000	434,107	—	—
Skelly	5,906	403	259	58	47	12	5,324	64,076	20,694	332	—	48,971	—	—
*Socony Mobil	10,335[1]	487[1]	306	81	46	10	16,447[4]	723,000	27,000[1]	976	897,000[12]	849,000[12]	8,775	10,448[1]
South Penn	779	138	94	39[14]	5	—	12,594	8,402	—	25	12,000	9,393	41	48
Southland Royalty	622	12	7	3	3	0	123	8,526	—	8	none	—	—	—
*Standard Calif.	63,263	646[10]	515	22	76	20	9,533[10]	854,892[4]	—	447[†]	650,500[10]	781,732	14,356	6524
*Standard Ind.	15,707	690	360	129	187	52	13,065	285,474	—	1,348	691,800	640,648[15]	2,189	12,982
*Standard N. J.	—	1,409	—	—	—	—	—	2,028,000	—	—	—	2,489,000	—	—
*Standard Ohio	1,400[1]	58	29	4	20	3	2,067	31,101	4,206	86	193,500	128,119	115	661
*Sun Oil	19,231	361	186	55	—	—	—	98,216	11,515	507	270,000	227,249	776	4,162
*Sunray Mid-Con	7,166	261	136	47	83	29	5,165	74,301	6,135	381	120,000	103,099	440	2,700
*Superior	—	105[6]	92	—	—	—	—	75,246	4,253	500	none	—	320	2,800
*Texas Co.	—	1,540[4]	1,150	151	—	—	23,945	1,100,726[4]	26,871	1,181[†]	997,100	829,186	3,678[10]	13,172[1]
*Texas Gulf	185	10	9	—	7	—	471	15,250	1,075	36	—	—	150	600
*Texas Pacific	1,358	68	35	14	—	—	—	18,504	—	—	none	—	105	525
Three States	717	15	12	1	—	—	—	2,772	—	35	—	—	—	—
*Tidewater	2,600	169	118	24	18	6	5,812	85,627	14,954	333[†]	284,500	192,222	637	3,285
TXL Corp.	1,973	89	77	1	11	4	226	9,674	—	23	—	—	—	—
*Union Calif.	3,023	180	81	30	79	27	3,911	93,088	6,433	253	190,000	164,518	525	2,919
*Union O & G La.	1,035	26	15	5	4	2	326	10,442	2,572	177	none	—	—	—
Universal Consol.	215	22	19	—	2	—	308	7,213	114	6	none	—	—	—
*White Eagle	1,324	31	20	4	5	3	713	3,114	—	18	none	—	—	—
Wilcox	166	59[4]	38	—	—	5	377	3,025	—	10	—	—	15	55
*Woodley	903	25	22	2	7	—	411	8,106	—	20	none	—	—	—
TOTAL								8,584,212				9,585,619		

*Has foreign operations
†Sales
‡Calendar day
[1]U. S. only
[2]Does not include concessions.
[3]U. S. and Canada
[4]Gross
[5]Does not include Hudson Bay Oil and Gas Co.
[6]Wholly owned
[7]213,099 b/d foreign.
[8]Includes exploration permits.
[9]Latest estimates. Some are earlier than 1958.
[10]Western Hemisphere
[11]U. S. and Canada
[12]Capacity is for consolidated companies only; runs include interest in non-consolidated companies
[13]Including 14 service wells
[14]Service wells
[15]Includes natural gas liquids.

has something to say about new methods in water flooding or other pressuring projects. Says General American "Secondary recovery of oil from depleted reservoirs has been successfully pursued on a wide scale, with your company operating 21 water flood projects and owning interest in 24 others."

Sunset International, which has been successful in several secondary recovery projects, reports "that virtually every property that is adaptable to water flood techniques is undergoing detailed study."

Sunray Mid-Continent said that its production department has formed 13 field-wide pressure maintenance and secondary recovery units involving company properties, which increased net development reserves by some 17 million barrels.

Reserves

Like figures on petrochemical sales are now, reserves were one time a well-guarded secret by nearly all oil companies. Now the majority of our 75 companies give estimates. As the Murphy Corporation says "There is difficulty of precise measurement and the impossibility of saying which of several recovery mechanisms may be at work in the new reservoirs." The report gave estimates of an outside firm and said "these are some 5 percent lower than those of company engineers."

More Than 50 Years

In this year of our industry's 100th anniversary, it is interesting to find so many oil companies have passed their golden anniversary. Here are the oldest companies:

Standard Oil (Ohio)	89 years
Atlantic Refining	88 years
Continental Oil	84 years
Tidewater Oil	80 years
Standard Oil of Calif.	80 years
Kendall Refining	77 years
Jersey Standard	76 years
Ohio Oil Co.	71 years
Texas Pacific Coal & Oil	70 years
Standard Oil (Ind.)	70 years
South Penn Oil	69 years
Union of California	68 years
Union Oil and Gas of La.	64 years
Sun Oil	58 years
Gulf Oil	58 years
Texaco	57 years
Blackwell Oil & Gas	54 years
British-American	52 years

Two will celebrate their 50th anniversary in 1960: Cities Service and Honolulu Oil Co.

Sunray Mid-Continent's report carried this Automatic Custody Transfer Unit photo. The units measure, sample and test more than 100,000 bbl of oil delivered to two D-X refineries each day.

Nortex Oil and Gas says of its reserves that they "continued upward during 1958 to 8,356,361 barrels of oil, including converted gas reserves. The reserves are recorded on the balance sheet at net cost, after depreciation and depletion of only $5,764,695, or 69c per barrel. This relatively low cost per barrel will have an increasingly beneficial effect on cash and net earnings during 1959 and subsequent years."

Aztec carries a table giving oil and gas reserves since its first year, 1954.

Refining

The double expense of curtailing production of a company's own crude, and hiking up its purchases cut deeply into net income. In its report, Frontier Refining said that the profit squeeze on product prices was because crude prices had the advantage of controls through state and governmental production, while products were on a free market. Said the refining company "American crude for some time has been priced out of the world market. Foreign crudes cannot only be produced at much lower costs per barrel, but can be transported to the East and Gulf Coast refineries of our country and refined into products at a saving or profit of from 60 cents to $1.00 a barrel versus domestic crude."

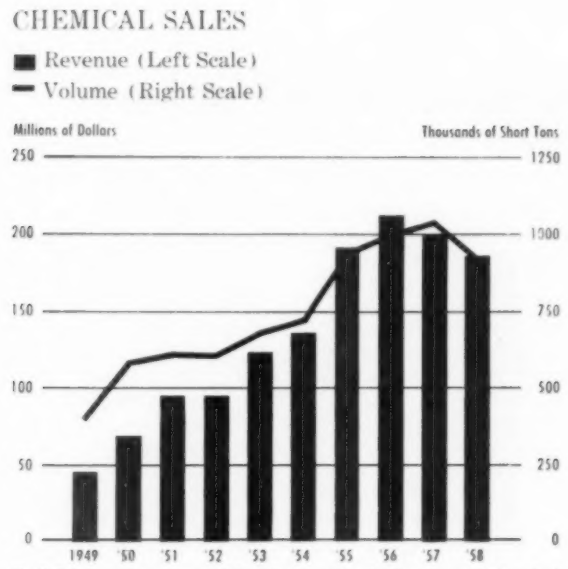
Quaker State Oil Refining's report mentions that the over-supply of Pennsylvania grade crude oil, which began in 1957, had continued in 1958. Difficulties were extreme early in the year, said the report, "when two refineries not associated with Quaker State, discontinued refining operations in the area. As a consequence of a surplus crude oil supply, Quaker State curtailed drilling and development of its properties and marginal tracts were disposed of or shut down temporarily."

Improvements paid off according to Shamrock. Its report said "The past year's operations have fully justified the company in its previous visions to increase its crude oil refining capacity and to add units in the refinery and gasoline plants to better utilize its raw materials. Substantial benefits were realized from operations of the butane isomerization plant completed in 1957, and from increased alkylate and sulfuric acid production as a result of plant additions completed in 1957 and early 1958."

Cosden Petroleum is looking ahead to more improvements at its refinery: "Presently we have under consideration the raising of additional funds principally to cover capital expenditures. We can providently spend $4,000,000 for improvements at Big Spring Refinery, which will pay out over a reasonably short period through reductions in costs without increase in capacity."

A refining company with expansion plans is Leonard. It reports "Since it is evident that octane levels will continue to rise, a 7500 barrel per day fluid catalytic cracking unit is being constructed. This unit will more than double the present catalytic cracking capacity . . . in addition Leonard is building a 1100 barrel per day alkylation unit (hydrofluoric acid catalyst)."

Several mentioned electronic com-



Shell Oil Company is one of few that supplies both volume of chemical production and revenue.

puters in operations. British American said this: "Extensive use is being made of electronic computers in planning refinery operations and co-ordinating the integrated supply plans of the Company. Post-graduate engineer and administrative training programs ensure that manufacturing operations are carried out in the most efficient and economical manner."

Petrochemicals

From the information we were able to obtain petrochemical sales are increasing. At the present time, however, this is not information that is readily available. One of the few that gives a complete breakdown on its chemical sales is Shell. We are reproducing here the chart it carries in its annual report, showing not only volume but revenue from chemical sales. It is exceptional in that it does not show an increase in 1958, but the change from 1957 is slight.

Gulf Oil Corporation reported that it had "kept pace with the petrochemical industry, increasing production and sales over 1957 levels by about 10 percent. Principal products manufactured and marketed were ethylene, propylene, isooctyl alcohol, sulfur, propylene tetramer, and toluene. Production of these and other Gulf petrochemicals follows Gulf's continuing plan of upgrading its raw materials to supply the chemical industry with the higher value intermediates which they require to produce a wide variety of industrial chemicals and consumer end products such as antifreeze, synthetic lubricants, rubber, plastics, detergents, and agricultural chemicals."

Standard Oil Company (Ohio) has increased its activities in the field of petrochemicals. A new company, Solar Nitrogen Chemicals, Inc. was organized and is owned jointly by Sohio and Atlas Powder Company. The new company will take over Sohio's ammonia plant and other facilities at Lima, Ohio.

Sohio will build a new plant at Lima also for the production of acrylonitrile from refinery products and ammonia. This plant, to be owned entirely by Sohio represents the result of five years search in this field. Acrylonitrile is used to make wool-like fibers, nitrile fibers for the rubber industry, etc.

Sun Oil report told of another chemical firm that was organized: "During the year your company also strengthened its position in the petrochemical field, a notable step being the establishment with Olin Mathieson Chemical Company of a jointly-owned affiliate, SunOlin Chemical Company, to construct a 72,000 ton urea plant."

Pipelines

One of the most interesting pipeline projects of 1958 is covered in the Monterey Oil Company report. It concerns the Trans-Western Pipeline Company in which Monterey holds one-third interest. The 1305-mile gas transmission system is being constructed from the gas-producing areas of West Texas and the Texas-Oklahoma Panhandle to the California-Arizona border.

The project will cost an estimated $193 million and will largely support its own financing. Upon completion, Trans-Western will deliver an initial daily average of 300 million cubic feet of 700-lb pressure gas to a terminal on the Colorado River at Topock, Arizona. Pacific Lighting Gas Company will be the sole customer and will distribute the gas.

Colorado Oil and Gas reports on the Jayhawk Pipeline Corporation which it manages and owns 50 percent. Read the report:

"Construction was commenced in May and the main system, consisting of 241 miles of 12-in. and 10-in. pipe, was placed in service in September. Jayhawk transports and delivers oil to the National Cooperative Refinery Association's refinery at McPherson and to our Derby refinery at Wichita. Connections exist with other pipelines through which it also supplies refineries in the great Midwest area."

Research

In 1957 there was a sharp increase in funds used for research. The 1958 figures, though information is meager, show a definite, if small rise.

Largest investment in research is made by Jersey. In 1958 it increased by almost 12 percent the funds devoted to this field. Its affiliates, Esso Research and Engineering, has a contract from the U. S. Department of Defense to develop high-energy, solid propellants for rockets, which may account for this important rise.

Texaco reported: "The Research and Technical Department's expenditures for the year were 9 percent more than in 1957." The report added: "The largest and most versatile nuclear radiation laboratory in American industry was placed in operation at the Texaco Research Center."

Explained Standard of California: "The company in 1958 expended about $17,800,000 on a variety of research projects and services. This figure approximated 1957 expenditures, reflecting the importance of maintaining long-range research programs regardless of temporary economic setbacks."

About its research program, Pure Oil reported: "Expenditures for research activities reached a new peak in 1958, totaling approximately $3 million. The Exploration and Production Research section was expanded substantially during the year. At year end there were 289 technical and clerical personnel at the Research Center."

Another company with high expenditures was Conoco. Read its report: "Continental's expenses for research and development activities reached a new high of $4.1 million in 1958, as compared with $3.8 million in 1957. Capital expenditures were $0.4 million in 1958 compared with $1.2 million in 1957."

Reports of experimentation, improvements, and new developments would fill many pages. This part of managements' reports to shareholders make fascinating reading even though there is a tendency to throw in more technical terms than the average stockholder may care to take on.

People and Policies

AS OHIO OIL Company's report says: "This annual accounting of the company's affairs must deal primarily with such things as dollars and barrels of oil. It is obvious, however, that the year's accomplishments and, more importantly, the future progress of the company depends basically upon the skills and actions and opinions of people, and upon the quality of relationships between the many groups of people concerned."

There are three areas of people relations for all oil corporations — shareholders who supply the money; employees who supply management and labor, and the public, which provides the customers, and in a "free" economy, indicates the regulations under which the industry must work.

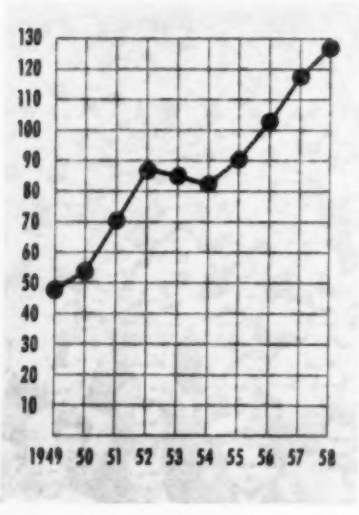
Shareholders

In 1958 shareholders continued to increase. Obviously the chief reason for appreciation of petroleum company shares was due to steadfast belief in the industry's future by a growing number of the public. In a "bad" year, number of shareholders increased 4 per cent. This was only half the percentage increase of 1957 over 1956.

The report of Phillips (which had almost 9 percent increase in stockholders) showed the graph below.

Sunray honored its 100,000 stockholder in May 1958. A cattle buyer from Iowa, he and his wife were flown to Tulsa as special guests at the annual meeting of shareholders.

STOCKHOLDER GROWTH
in thousands



Phillips Petroleum Company has large increase in number owning shares.

Employees

The trend toward rising employment was stopped and reversed in 1958. Employment showed a 4 percent decline in oil concerns.

Companies whose reports mentioned this explained how reduction of their staffs was accomplished. Standard of California said: "To protect employees' jobs in the face of the year's economic decline, the company instituted a manpower stabilization program under which replacement of retiring or terminating employees was curtailed. Total employment was thereby reduced without the necessity of general layoffs in any operation."

Humble had this to say:

"Because of the sharp decline in operations, a reduction in personnel became necessary beyond what could be achieved through normal attrition. After a careful analysis of the problem, in which consideration was given to the welfare of all employees concerned, a special voluntary retirement program was offered to employees 55 years of age or older. It included a partial absorption by the company of the annuity discount caused by early retirement. For employees with short service who were laid off, there was adopted a severance settlement plan based on years of service with the company."

Payroll and benefits were higher in spite of cuts in employment. Conoco advised: "The increase stemmed largely from the full-year effect of the 6 percent general increase in wages granted during the spring of 1957. An additional 5 percent general increase in wages was granted effective January 16, 1959."

Large and small companies referred to the rise in wages and pointed out that this must come from still unfirm earnings.

Last year, before the 5 percent wage increase, average per employee had risen to $6,670 a year from $6,544 in 1957. This in spite of crippled earnings.

Management Policies

Many reports cover organization and management in their messages to stockholders. This seems a good idea as shares in a company are often bought on the basis of management efficiency.

This paragraph is from Honolulu Oil Company's report:

"During the past several months the management has conducted an inside survey of company policies and procedures. This survey was performed by working groups of personnel selected from various levels and departments under the guidance of an outside experienced consultant. The results to date have been most encouraging and the ultimate increase in operating efficiency should be very beneficial to the future success of the company and its employees. The policy of constant attention to the well-being of the employees and their families will be continued."

Delhi-Taylor's report included as important events of the year:

"1. A clear-cut statement of policy by the Board of Directors will serve as a platform for future development.

"2. Streamlining of the organization for better flexibility, coordination, and efficiency."

An organization chart is carried in the Delhi-Taylor report which "suggests the speed with which information can now flow between the executive officers and operating departments. This enables your management to make prompt and effective decisions."

Argo Oil begins its report with a title, "the Argo team." The experiences and background of the team are itemized with such particulars as:

"Fourteen technical personnel in the production department have a total of 157 years of experience. Their average age is 38 and they all hold engineering degrees.

"In the geological department, 14 geologists hold 21 degrees. Seven of these are masters degrees. The geologists average 36 years of age and average 10.5 years experience.

Aid to Education is reported by several companies. Gulf said:

"During 1958 almost three quarters of a million dollars were contributed by the company to various educational institutions. The new six-part Aid to Education program to help American colleges and universities was in effect for its first full year in 1958."

Safety was much reported on. This is Union of California's coverage:

"Our employees maintained an excellent safety record during 1958. Both the frequency and the severity of injuries on the job were at a low level and substantially below the industry average. A program to emphasize

TABLE 4. PEOPLE IN PETROLEUM.

Company	Holders of common stock[1]		Employees, avg.		Payrolls & benefits ($1000)	
	1957	1958	1957	1958	1957	1958
Amerada	10,467	—	2,148	—	—	—
Anderson-Prichard	5,900	7,000	989[1]	917[1]	6,658	6,534
Ashland O & R	37,960	38,766	4,800	4,600	—	—
Atlantic Ref.	52,243	51,923	16,790	16,247	113,263[2]	112,747[2]
Aztec O & G	7,333	7,989	35	35	—	—
Bishop Oil	890	647	85	85	—	—
British-American	31,206	34,975	8,064	7,660	44,184	40,000
Champlin O & R	18,233	18,290	1,615	1,507	10,959	11,044
Coastal States	2,089	2,616	115	141	317	447
Colorado O & G	7,497	7,097	630	660	3,698	4,181
Continental Oil	30,504	31,017	9,978	9,973	70,340	70,763
Cosden Petroleum	6,785	8,100	949	956	4,918	6,138
Delhi-Taylor	10,400	12,000	685	649	4,671	4,799
Douglas of Calif.	1,625	1,796	533	460	3,122	2,704
Drilling & Explor.	2,200	2,200	395	383	3,457	2,856
Eason Oil	510	516	125	131	—	—
Frontier Refining	1,456	1,798	483	505	—	—
General American	4,489	4,594	642	611	3,269	3,279
General Crude	1,053	1,143	221	212	1,514	1,566
Gulf Oil	90,404	93,580	61,100	56,000	311,326	312,752
Honolulu Oil	4,736	4,711	655	667	5,179	5,407
Hugoton Prod.	5,300	5,100	75	75	—	—
Husky Oil	2,303	2,923	904	788	4,090	4,038
Intex Oil	1,071	1,087	88	84	723	687
Kendall Ref.	2,664	2,709	726	685	3,857	3,774
Kerr-McGee	5,643	5,736	2,750	2,981	13,699	17,753
Leonard Ref.	4,693	4,497	683	667	4,764	4,874
Louisiana Ld. & Exp.	9,424	9,751	110	115	901	1,010
Midwest Oil	7,445	7,353	116	127	1,008	1,151
Monterey	4,590	4,609	402	382	3,036	3,159
Murphy Corp.	1,303	1,372	585	632	2,713	3,671
Ohio Oil	43,726	43,514	6,582	6,453	44,707	44,256
Phillips Petroleum	117,619	127,749	26,838	24,459	192,506	182,789
Plymouth Oil	8,318	8,676	1,063	938	8,021	7,596
Pure Oil	43,534	46,078	11,705	10,981	69,136	67,833
Quaker State	6,306	6,502	1,474	1,398	7,599	7,397
Richfield Oil	11,995	11,783	6,177[1]	6,260[1]	41,287	43,694
Shamrock O & G	6,468	6,735	978	962	6,000	6,400
Shell Oil	19,685	19,307	40,465[1]	38,572[1]	325,814	325,352
Signal O & G	9,288	10,760	1,694	1,691	11,945	12,211
Sinclair Oil	115,502	116,165	25,191	23,828	167,335	165,002
Skelly Oil	6,087	5,857	4,826	4,817	31,352	31,173
Socony Mobil	202,000	207,000	45,200[3]	43,700[3]	355,800[3]	357,100[3]
South Penn	10,187	10,459	2,390	2,323	12,407	12,456
Southland Royalty	1,728	1,750	47	45	436	483
Standard Calif.	148,315	152,754	40,121[1]	38,395[1]	276,850	280,624
Standard Ind.	148,375	151,937	49,678	46,033	370,128	352,469
Standard N. J.	463,000	503,000	160,000	154,000	993,000	953,000
Standard Ohio	37,797	37,535	11,587	11,138	74,263	76,682
Sun Oil	24,340	25,954	19,090[4]	18,408[4]	124,600[2]	121,309[2]
Sunray Mid-Con.	103,810	105,575	5,704	5,599	36,942	36,653
Superior Oil	2,300	2,300	3,046	2,738	—	—
Texaco	135,164	138,374	53,176	53,702	307,258	319,827
Texas Pacific	5,564	5,402	462	474	—	—
Tidewater	19,796	20,911	9,763	9,459	61,785	62,297
TXL Oil Corp.	8,000	8,100	55	68	—	—
Union Oil of Calif.	52,000	52,000	8,543	7,873	64,062	60,925
Union O & G of La.	1,450	1,352	413	418	2,736	—
Universal Consol.	2,500	2,900	120	83	775	791
White Eagle	3,400	3,500	648	625	3,174	2,953
Wilcox Oil	1,929	2,022	139	122	827	798
Woodley Pet.	1,641	1,685	79	83	592	623
TOTAL	2,123,663	2,213,522	652,582	624,590	4,204,003	4,165,777

[1] At year end.
[2] Payroll only.
[3] U.S. only.
[4] Oil Division.

safety off the job was initiated and will continue in 1959."

Advertising was mentioned by Sinclair, which received a number of awards for its four-year advertising campaign devoted to conservation of America's natural resources and historic shrines.

Management development was underscored as never before. Read one report:

"Socony Mobil is continuing to make advances in its executive development program. To foster the well-rounded development of our key people, we are assigning more of them to jobs in phases of our operation new to them. In addition, we conduct two courses in management development. Over the past five years, nearly 2300 managers and potential managers have completed "Mobil Principles and Methods of Supervision" and nearly 1200 our "Organization and Management" course. In the same period, 50 of our top executives have taken intensive advanced management courses at 10 outstanding universities."

Texaco told about its managerial conferences to increase knowledge of the company and develop abilities:

"For a number of years the company has had several programs in effect to enlarge its reservoir of managerial talent. In May, a series of Texaco conferences was inaugurated at Houston, Texas, for personnel at the managerial level of all departments. The purpose of these conferences is to broaden participants' knowledge of the company's over-all operation and to better prepare them for increased responsibilities."

Sun Oil gave this report of results of its extensive supervisory development program:

"The measured success of this program is reassurance that Sun's front-line supervisors not only have the competency to handle today's problems, but also the opportunity to grow within the company. Evaluation of the program showed that supervisors improved many skills and developed more initiative in assuming greater job responsibilities."

Public relations was the subject of several management reports to stockholders. Plymouth called on all petroleum people to help, stating:

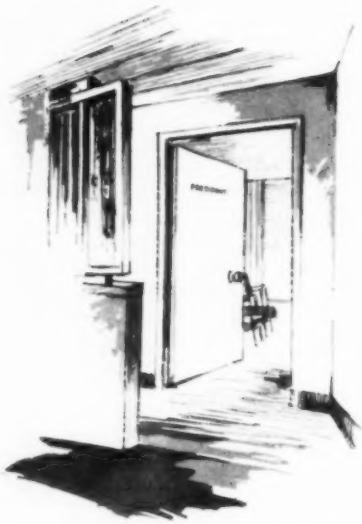
"It is the job of all those having a stake in the petroleum industry — investors, employees, royalty owners and suppliers — to bring about a fair and realistic public appraisal of the industry and its importance to the welfare and security of the nation. Once that is achieved, the industry will be in a position to continue to meet its public responsibilities as it has throughout the last century."

Jersey Standard gave some indication of its activities in public relations with this paragraph:

"It is important for groups of many kinds and the public in general to understand the company's actions and the need for a healthy business climate in which to operate. During the year company officials appeared before legislative committees to testify on matters such as tax, trade, and other policies affecting the national welfare as well as the company's business. Statements were circulated concerning issues influencing Jersey, and steps were taken to inform interested parties of the significance of these issues. In addition, company employees at all levels were encouraged to participate in local and national civic undertakings and to develop better understanding of the effect of political developments upon them and their jobs."

Thus did most annual report close — with people and their relation to the company, as shareholders, employees, and customers.

Outlook



"Letter to the Stockholders" a sketch from Blackwell Oil and Gas report.

OF COURSE, management is not going to tell a stockholder to sell out — but annual reports are certainly not propaganda. Management presents surprisingly frank appraisals of problems and evaluates pretty accurately the potential of the future.

Laid on the line is Texas Gulf Producing's statement:

"Reductions in the selling price of crude oil, together with increases in the price of materials and supplies, continue to plague the domestic producer. Our selling price of crude oil has declined 13 cents a barrel at a time when we were obliged to raise wages by about 5 percent, again increasing our cost of doing business. This combination is eroding the foundation of the domestic industry by eliminating the incentive to find new reserves."

Outlook for the producing company has been questioned, but Texas Pacific Coal and Oil sees the domestic producer with good advantages. Says its report:

"The results of the past three years, the indications of current economic studies and the forecast for the future all point to the continued importance of the independent domestic oil producer. Companies in this category continue to show the industry's highest percentage of gross income and earnings, and continue to exceed the industry average in rate of oil discoveries and additions to reserves. As each year brings a greater threat of conflict abroad, which could result in a reduction or even total elimination of oil and crude supplies from foreign sources, the stable and successful independent domestic producer is more important to our national safety and economy than ever before."

Outlook for business and industry is improved, reports Texaco's management. "We anticipate that domestic demand for petroleum products will increase about 4 percent and foreign free world 9 percent.

"However, the long-term outlook in the United States is somewhat clouded by the continued prospect of inflation, higher wage and material costs, and the narrowing of profit margins. Industry in general is deeply concerned by the increasing ability of organized labor to force inflationary wage increases that are clearly in excess of gains in productivity. Fortunately, more and more of our citizens are becoming aware of this threat to our economic stability."

In the opinion of Standard of California management, early in '59 "supply-demand ratios were generally in better balance than at the same time in 1958. Demand for petroleum products in the United States is expected to increase this year by nearly 5 percent, and in Free Foreign areas by about 9 percent. It is to be expected, however, that in the short term these favorable factors will be offset to some extent by increasing competition for domestic and foreign markets; rising labor costs; and the problems of over-supply abroad, both in oil and in the tankers that transport it."

One of the problems discussed is Federal Power Commission's control of interstate gas sales. Champlin's report states:

"Stockholders should be aware that the present unworkable utility regulation of natural gas producers is costly to the company and to the government alike. There continues to be a real need for sensible amendatory legislation."

Amerada explains the predicament: "The burden and cost of preparing and handling rate cases before the Federal Power Commission are constantly increasing. No new contract for the sale of gas in interstate commerce can now be made by the Corporation with any assurance as to the price it will be permitted to receive. Furthermore, under existing contracts the Corporation has had price increases for gas suspended in about 30 instances with no assurance of what prices will be approved, how such prices will be determined, or when they will be acted upon. Our experience is no different from that of most producers selling gas in interstate commerce, with the sum total of the uncertainty, delay, obstacles and expense to the industry becoming increasingly burdensome."

Inflation gets a spot in several reports. States Phillips Petroleum: "A problem confronting the oil industry and certainly one critical to all industry — indeed, to all citizens — is inflation. Among the causes are wage increases which do not result in proportionate gains in productivity and unnecessary government spending. Higher prices are needed now to recover the general 5 percent wage increase of early 1959."

Pure Oil turns to the problems and challenges ahead after reminding its stockholders: "The United States is the largest consumer of energy the world has ever known. Virtually all the energy our nation uses comes from the basic resources of water power, coal, oil or natural gas. Of the total energy needed by our country over two-thirds is provided by oil and natural gas . . . The national thirst for oil and natural gas grows greater and greater. A recent study estimates that U. S. consumption of oil and natural gas will increase from the equivalent of 13.7 million barrels a day in 1957 to 22 million in 1967."

Drilexco also feels the industry must prepare for the long term. Its report says, "Present problems of the petroleum industry are extremely complex, some of them appearing to defy satisfactory solution. The management of your Company feels, however, that due to demands for new oil and gas reserves which will be placed upon the industry by a growing economy and continuing increases in population, the long range prospects are promising."

In spite of threats to a prosperous future, the present gives solid evidence that financial progress is with us. The last of 1958 pointed to the uptrend. Atlantic Refining, for instance, reported a $26,158,000 net income in the second half compared to $7,667,000 profit for the first half.

Plymouth's net income for the last quarter of last year exceeded that of the entire first half.

First quarter of 1959 reveals a substantial increase in revenue and in earnings for those whose reports have been made.

The 1958 experience has pared the deadwood and oil company organizations appear to be running more smoothly, more efficiently and more profitably than they were a year ago.

IS A 35-HOUR WORKWEEK ENOUGH?

Labor demands short hours to spread work . . . Management invests deeply in technological advances to cut labor costs . . . Can this be settled only by the federal government?

Haig Babian

TWO YEARS AGO, peppery Walter Reuther led his automobile workers in a bold uphill attack against the ramparts of the 40-hour workweek. Like the king of France in fabled song, he "marched up the hill, and marched right back again." In other words, he got nowhere. Recently, however, the shorter workweek received the blessing of the entire AFL-CIO Executive Council. It was George Meany himself who posed the terrible alternative if the workweek is not reduced. Either we do, or we have to shoot a couple of million workers, according to Meany.

Let us examine labor's case first. I think it would be fair to say that labor's call for a 35-hour workweek—because we produce more than we can consume at full employment levels—has the tinge of a latter-day Luddite revolt, or at least something more than a tinge of the "spread the work" plan. Better tools, machinery, automation—these are at the base of the problem of labor displacement. So far, so good. But labor also is thumping for full employment and full production to meet the needs of a growing America. *Now, is it not true that "spreading the work," overmanning our machines and cutting down on the workweek would result in as much underutilization of resources as having five million unemployed?* Is it not true that America can be greater, stronger and a better place to live in if we produce as much as we possibly can? Since the entire physical value of the U.S.A. comes to only about $20,000 per American family, is it possible that we have *too little production*, and not too much as George Meany tells us?

By way of continuing this examination of labor's case, it readily comes to mind that during the past 10 years the production industries have shown a 7 percent net loss in employment, while the service people have enjoyed a 17 percent net gain. To date, only 15 percent of organized labor is comprised of the so-called white collar workers, and the unions are notorious for their continued lack of success among this class of employees. *Thus, is organized labor proposing to maintain itself, even at the price of insisting that production workers who are no longer needed nevertheless be kept on by "spreading the work"?*

Now let us turn to management. Not even the major industrial or manufacturing businesses will now dispute the fact that in this postrecession era they will need fewer workers for more production, with better technology cited as a specific reason for the progress in their productivity rates. The failure to rehire all who were laid off during the recession is not merely a reflection of a recession-induced increase in productivity. It is in keeping with the postwar trend unmistakable in the figures cited above.

Yet, two years ago, management's rebuttals to Reuther's demands for a shorter workweek were full of allusions to how many more automobile workers there are today than blacksmiths, who were displaced. In other words, what was bad for the blacksmith was good for the automobile worker. *But is it not now possible that the automobile worker is doomed to the same fate as the blacksmith?*

The problem of displacement is a very real one. Declaring a 35-hour workweek will not solve it, nor will citing the ancient history of the Industrial Revolution solve it.

What would have happened if management had invested a part of the sums allocated for technological advances to programs of retraining personnel who eventually must face displacement? Such programs could have prevented investment in overcapacity, and would cost no more than the protective benefits demanded by unions, or the shorter workweek, for that matter.

Ought not competitors vie with each other to develop new ideas about the sociological effects of technological goals — as much as they vie with one another in the field of modernizing plant and equipment?

The interesting thing about whether there should or should not be a shorter workweek now is not in the issue of who is right and who is wrong. Far more intriguing is how this question presents us with *still another example of an intramural conflict in contemporary American society that will have to be settled by the federal government* — and only because loyalty to traditional thinking ties the hands of men who should know better.

I realize it is difficult to change course, to seem to violate established traditions, institutions and practices. Unfortunately, it is precisely this difficulty that forever leads us to the halls of government to find the resolution of our problems. As we continue this process decade after decade, what then will become of the traditions that we as a society value the most? ★ ★ ★

Condensed from an editorial by Haig Babian, Editor of Economic Affairs, published by Institute of Economic Affairs, New York University.

NATIONAL EMERGENCY COMMITTEE SET UP

NPC undertakes to review plan for handling oil and gas in crises

WALTER S. HALLANAN, chairman of the National Petroleum Council, has appointed the highly important special Committee on National Emergency Oil and Gas Mobilization and seven Regional Petroleum and Gas Sub-Committees, one for each of the geographical regions established by the Office of Civil and Defense Mobilization.

The committee was formed as result of a request received from Elmer F. Bennett, Acting Secretary of Interior, January 21, 1959. Secretary Bennett asked the Council:

1. To undertake a review of the "Proposed Plan of the Office of Oil and Gas for Handling Petroleum and Gas During a National Emergency," submitting such comments and recommendations as it deems appropriate for consideration in possible future revisions of the plan.

2. To supply names and industry affiliation of individuals qualified to discharge the responsibilities of specified positions in connection with this "Proposed Plan" as full-time government employees in the event of a national emergency.

The committee is under the chairmanship of Mr. Hallanan, Plymouth Oil, with R. G. Follis, Standard Oil of California, serving as vice chairman. Two Special Assistants to the Chairman are J. Ed Warren, Cities Service Company, and Dr. Robert E. Wilson, Chicago, formerly of the Standard Oil Company (Indiana). Committee Secretary is James V. Brown, National Petroleum Council.

The complete membership list for the Committee on National Emergency Oil and Gas Mobilization, and its Regional Subcommittees is given in the chart.

By letter of March 11, 1959, Captain Matthew V. Carson, recently designated government co-chairman of the council by Secretary Seaton, approved the establishment and membership of this committee and its subcommittees, and designated Frederick S. Lott, assistant director of the Office of Oil and Gas, Department of Interior, as government co-chairman of the main committee. ★ ★ ★

National Petroleum Council Committee on National Emergency Oil and Gas Mobilization

*Chairman — Walter S. Hallanan
Vice Chairman — R. G. Follis
Special Assistants to the Chairman — J. Ed Warren, Robert E. Wilson
Secretary — James V. Brown

*Government Co-Chairman of Committee — Frederick S. Lott, Office of Oil and Gas, Department of Interior.

P. C. Spencer, Chairman, Region 1*
J. C. Donnell, II, Chairman, Region 2
C. Pratt Rather, Chairman, Region 3
Reid Brazell, Chairman, Region 4
Bruce K. Brown, Chairman, Region 5
Glenn E. Nielson, Chairman, Region 6 and 8
D. T. Staples, Chairman, Region 7
*Also member of Agenda Committee

A. Jacobsen, Chairman, Agenda Committee
Frank M. Porter, Chairman, Appointments Committee
Morgan J. Davis, Chairman, Committee on Use of Radio and Radar (1959)
R. L. Milligan, Chairman, Committee on Petroleum Storage Facilities (1959)

Agenda Committee Members

Russell B. Brown, Paul Endacott, B. A. Hardey, W. Alton Jones, J. Howard Marshall, L. F. McCollum, B. L. Majewski, J. R. Parten, M. J. Rathbone

REGIONAL PETROLEUM AND GAS SUB-COMMITTEES

OCDM REGION 1	OCDM REGION 2	OCDM REGION 3	OCDM REGION 4	OCDM REGION 5	OCDM REGION 6 & 8	OCDM REGION 7
Ch.—P. C. Spencer	Ch.—J. C. Donnell, II	Ch.—C. P. Rather	Ch.—R. Brazell	Ch.—B. K. Brown	Ch.—G. E. Nielson	Ch.—D. T. Staples
V. Ch.—J. Comerford	V.Ch.—W.W. Vandeveer	V. Ch.—J. H. White	V.Ch.—B.L.Majewski	V. Ch.—J. R. Parten	V. Ch.—A. F. Barrett	V. Ch.—S. Fox
Sec.—V. M. Brown	Sec.—V. M. Brown	Sec.—V. M. Brown	Sec.—V. M. Brown	Sec.—J. V. Brown	Sec.—J. V. Brown	Sec.—J. V. Brown
Bergfors, F. E., Sr.	Benedum, P. G.	Cummins, J. F.	Dunnigan, J. P.	Anderson, R. O.	Clark, G. W.	Cranson, L. A.
Burns, H. S. M.	Blaustein, J.	Duke, G.	Fisher, M. M.	Baldridge, E.	Cowden, H. A.	Follis, R. G.
Harper, J.	Brown, R. B.	Wrather, J.	Graves, B. C.	Ball, M. T.	Downing, W. M.	Goggin, G. T.
Hilts, H. B.	Dow, F. B.		Hartman, I. W.	Bridwell, J. S.	Mills, M., Sr.	Graves, B. I.
Jacobsen, A.	Foster, C. T.		Hawley, C. B.	Carpenter, O. S.	O'Shaughnessy, J. F.	Green, R. H.
Jones, W. A.	Hallanan, W. S.		McClure, H. M., Jr.	Davis, M. J.	Ritchie, A. S.	Jones, C. S.
Long, A. C.	Hunter, G. B.		Milligan, R. L.	Endacott, P.	Robineau, M. H.	Taylor, R. H.
Ludwig, D. K.	Jones, J. P.		Nolan, J. L.	Goldston, W. J.		
Maguire, W. G.	Niness, S. F.		Prior, F. O.	Hamon, J. L.		
Matthewman, J. L.	Proctor, D.		White, H. D.	Hardey, B. A.		
Nickerson, A. L.	Supplee, H., Jr.		Wilsey, L. A.	Huley, D. A.		
Pogue, J. E.	Violette, W. G.			Kayser, P.		
Porter, F. M.	Vockel, S. M.			Keeler, W. W.		
Rathbone, M. J.	Wells, E.			Kennedy, H. J.		
Warren, J. E.	Wolfe, J. T.			Lawton, R. G.		
Young, G. S.				Locke, E. R.		
				McCollum, L. F.		
				McGowen, N. C.		
				Marshall, J. H.		
				Moncrief, W. A.		
				Nixon, M.		
				Powell, W. T.		
				Richardson, S. W.		
				Rodman, R. V.		
				Rowan, A. H.		
				Simpson, G.		
				Tennison, G. T.		
				Whaley, W. C.		
				Windfohr, R. F.		
				Zeppa, J.		

NOTE: Members of Regional Petroleum and Gas Subcommittees are not limited to participation in the Region to which they have been named, but may participate in any other Regional Subcommittee in which they wish to supply information or assistance.

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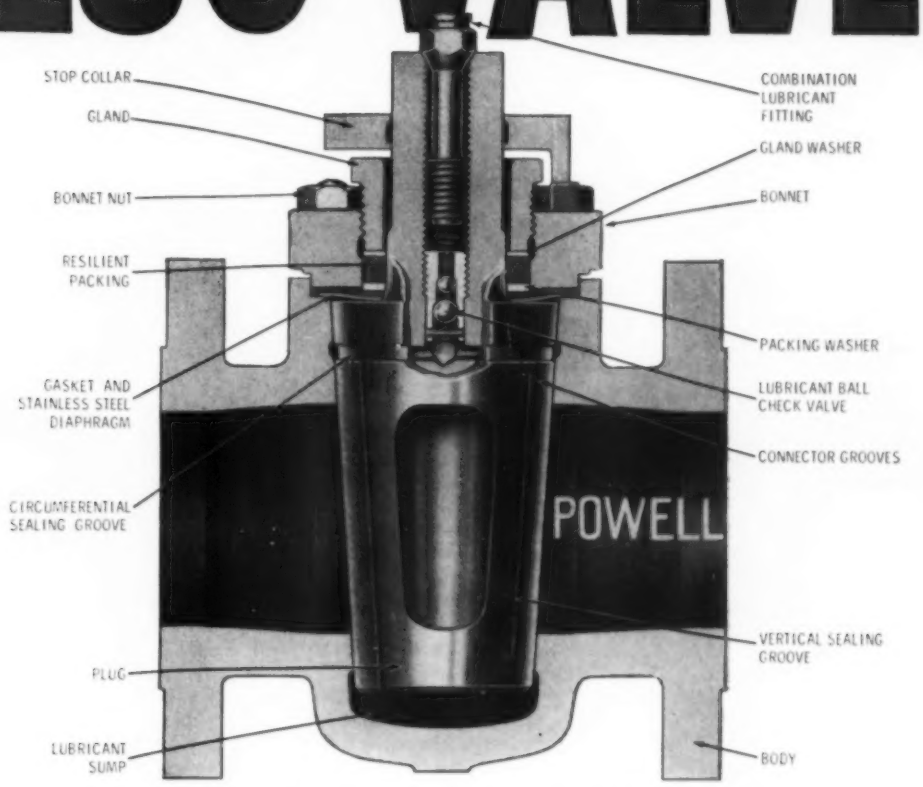
LUBRICATED PLUG VALVES



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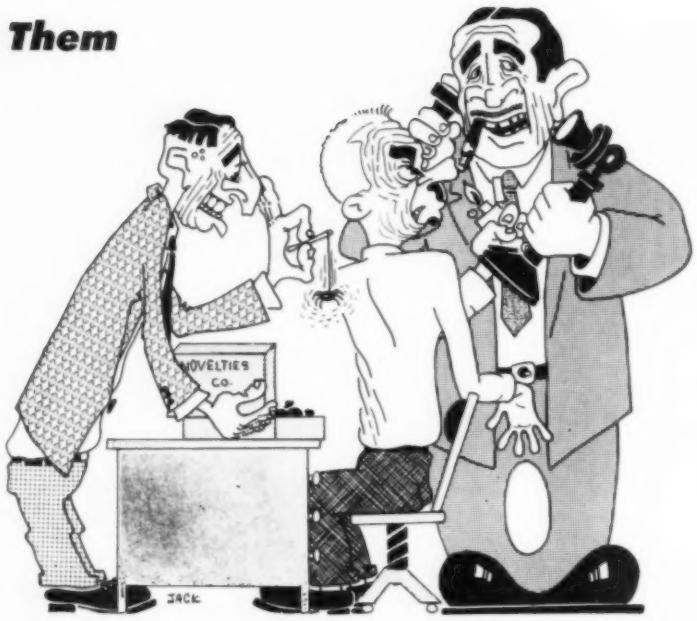
Plagued by Pests?

Office Pests . . . How to Control Them

Ernest W. Fair



JUST as our home life is badly disrupted by pests — in this case insects and rodents — so our office life is continuously harassed and disrupted by pests of the human variety. And, just as there are effective pest control methods to handle the household pests, so there are control methods to successfully exterminate those which infest the office. Here are the more common types and suggestions for their control:

Pete the Peddler is a pest that will probably always be with us. Distinct from the supplier salesmen, he serves little useful purpose, and has nothing of real value to offer. Signs do not discourage him; hard looks are his meat. He disrupts employees' work, wastes their time, prevails on their sympathy, and pockets their pennies. The best formula to use on this individual is a little guile and deceit, i.e., inform him Mr. or Miss So-and-So handles all such matters and is out at present, or company policy prohibits individual employee contacts. An effective control can sometimes be achieved by an alert office receptionist.

Don the Juan is the variety who is convinced that he has irresistable charm that the receptionist and other women in the office must share and who not only annoys them continuously but disrupts office routine. Trying to handle this pest with kindness and good manners only encourages him in the certainty he has made another conquest. Sharp jibes and ridicule of his charms will prove much more effective. Sometimes, it is necessary for the personnel manager to suggest that he pay more attention to his job and less to his co-workers.

Betty the Borrower is another deadly inter-office pest that should be recognized early and discouraged forthwith, or all supplies and portable office equipment will be in her office before you realize what has happened. *Sure, be glad to let you use it here, but I have to use it myself in a little while,* is one way to discourage her. Another is to be always "out" or down to the last "two or three" of the requested item. Saying "no" and saying it from the very start is a sure way to discourage this individual, for if she cannot get results she will soon find another victim.

Tom the Telephoner exists in every major office set-up. Many a time an important call has been missed in the office while Tom argued with his girl, or a credit manager over your telephone. One polite way of saying no is *I'm sorry but our telephone is out of order,* and should it suddenly ring, coming back with *Oh, there it's fixed,* answering quickly and hanging on as long as possible. Another answer is: *"I'm so sorry but Mr. So-and-So has asked that there be no out-going calls for the next hour, he's expecting a very important call any minute.*

Peg the Postage Pest costs every office a sizable sum of money over a year's time with her petty filching of "just one stamp" mighty often. Not keeping stamps is of course the obvious answer. Not as drastic, but as effective is putting one person in charge of stamps and keeping track of outgoing mail is another answer. *Just leave the money with the letter at the mail room and they'll mail it for you at the post office when they go,* is the answer one office manager gives this type pest.

Gossipin' Gert is another breed of time killers that always leaves a bad taste in one's mouth after her visit. When such a pest has been recognized for the pest she is, you can always be too busy to listen, ignore her, or say you have already heard the news. Or, you can take the straight forward approach and tell her you prefer to mind your own business and would appreciate her doing likewise.

Louis the Lounger who decides that your office is a good place to loaf around, "shoot the breeze," spend a second, third or fourth coffee break, etc., is a pest of the more subtle kind. He disrupts your work, and is a bad influence on the other office personnel who have work to do. Seeing that such an individual is placed in the most uncomfortable chair available, is one tactic. Inviting him out for a cup of coffee and hurrying off before he can get his first sip is another way of detouring this pest. Making a telephone call or

two and paying no attention to him, suddenly remembering an appointment, or informing your secretary to bring a contract or special file in when he appears with *Here's the file you wanted Mr. So-and-So* are also effective ruses.

Clarence the (Self-Appointed) Crusader and his progeny seem to be on the prowl in every kind and type of office. With their portable soap boxes they descend upon you. They are usually difficult to handle and always unreasonable. *Mr. So-and-So sets aside Saturday mornings to see folks on such matters,* is one answer to give, or if they should come back then Mr. So-and-So can always be called away to the bedside of a sick aunt. If they decide to pour forth their message on the personnel, turning a deaf ear to them is about all we can do; most will soon go away when they lose their audience.

Freddy the Friend who has nothing better to do than hang around the office needs discouraging as much as any other pest; particularly the male variety seeking feminine companionship in the office. The best formula to exterminate the office of these pests has to be applied by the employees with whom they are visiting. When it is clear to such an employee that the office is a place to work, and visitors should be handled after office hours, then the individual employee can generally handle the problem and most certainly will handle it if he or she knows their very job depends upon getting rid of "Freddy" during office hours.

Elmer the Efficiency Expert who keeps coming into the office and showing everyone how to do something *better* is another pest of irksome caliber. Usually this Elmer is a rude individual and understands only rude treatment. Sometimes he is a mild-mannered *do 'em gooder*. In the latter case, if we will take the time to listen attentively two or three times, and then absolutely ignore the instructions we will discourage him. He thrives only on seeing someone else's system supplanted by his own, and will move to other "greener pastures" when he can't obtain results in your office.

Such pests as these have no place in any busy office. Not only do they disturb the established routine, but they are a constant source of friction, jangled nerves, and in the long run a very unnecessary item of office overhead.

Handling them with the "insecticides" will take care of the situation in nine cases out of ten. The tenth case will take some doing, i.e., individual handling of the individual problem; but it is worth all of the effort required to get the job done. ★ ★ ★

"Business Needs to Bring Balance To American System" — Greenewalt

Historic balances assure rights, curb excesses, and offset efforts by any group to benefit at expense of others . . . Without the weight of business the nation is maladjusted, says DuPont president.

A NEW ATTITUDE toward politics, coupled with "positive and affirmative doctrines" which fit acceptable national objectives, was urged upon businessmen by Crawford H. Greenewalt, president of the Du Pont Company.

Indifference to political issues among businessmen has upset the historic balances essential to democracy, Greenewalt declared. He noted that "a list in any direction, if long protracted, brings distortions as well as inequities." Society itself, he said, is the loser, as a "heavy thumb on the scales" can result only in "short measure for the customer."

By presenting its own case "in whispers," business has produced a social maladjustment for "it is obviously essential that their point of view, representing the largest and most widespread influence in our national life should be clearly expressed," he said.

Businessmen cannot expect support unless they "let it be known what they stand for," he said, adding that "government, like parenthood, requires personal attention" and that there could be no delegation of the "responsibility to be responsible."

Closer contact and understanding was seen as the cure for hostile attitudes on both sides of the business-government relationship. Businessmen have too often approached politics "more in anger than in reason," while politics has mistakenly looked askance at the "business viewpoint." Actually, no "representative" business viewpoint exists and there are "all manner of opinions" to be found on public questions, even within a single corporation. Business people can, however, make "constructive contributions to government, advancing the interests not simply of business, but of public welfare in general."

But he cautioned: "Politics is not an instrument of power; it is, first of all, an instrument of persuasion, of communication."

As business enters the political arena, it "will perform its greatest service by restoring balance to the traditional American system." When the historic balances of the nation are in proper relation, rights are assured, excesses are curbed and they offset efforts by any group to benefit at the expense of the others, he said, and noted John Adams' warning that anything else is to "commit the lamb to the custody of the wolf."

"An adequate balance among industry, agriculture, and all other pursuits has been at the heart of the American economic system just as a consolidation of many diverse viewpoints has been the marrow of our political system. And the same need exists undiminished today in both categories, just as it has at all time in our history."

If the balances are to be preserved, "all parties should be heard and considered. Yet business, in an era featured by shrill cries, has all too often pleaded its case in whispers," he said.

"Why businessmen should have been diffident about speaking out in defense of their cause, I can't say," he added. "Had the privilege of a hearing been removed by law, the injustice would have been decried as an outrage. Yet, as Mark Twain once said about reading, there is little difference between those who don't and those who can't."

He noted also that, too often businessmen in politics "approach this delicate area more in anger than in reason, with an atmosphere of conflict about them."

"What one must remember is that the other elements in the economic system which are actively promoting their own causes have every right — and indeed every responsibility — to do so. The cue for business is to add its own song to the chorus."

"In our country, all decisions are made in accordance with popular will," Greenewalt continued. "I believe that, by and large, the public's verdict will be sound and just. But here, of course, there is one essential proviso, that the issue be clearly defined and that the voters be fully and completely informed of the facts. And it is here that business has the obligation and the duty to make sure that evidence is not withheld which would hinder the jury in reaching fair and equitable conclusions."

★ ★ ★

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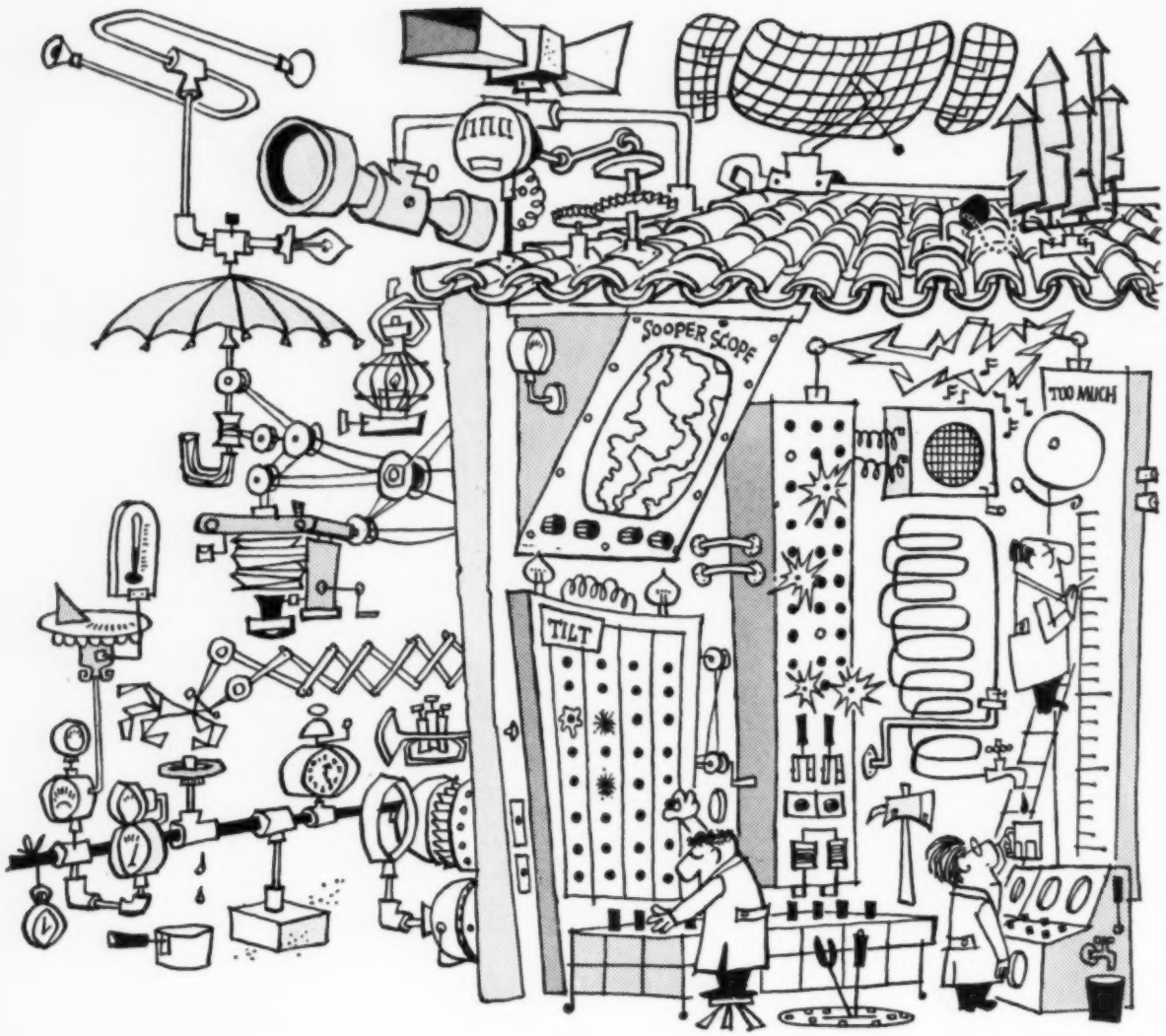

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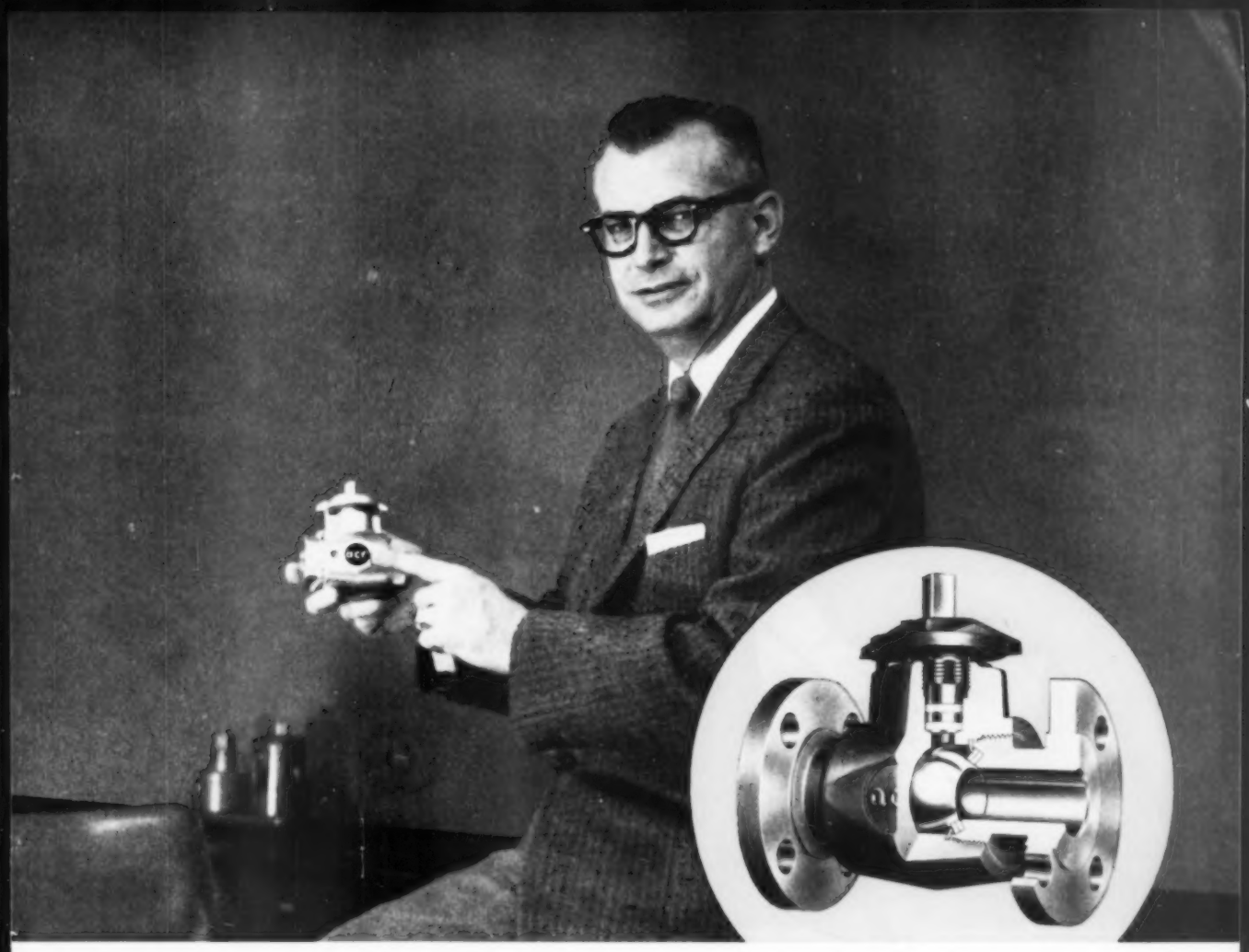

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What About Management Courses?

Gilbert C. Jacobus

"The man who knows principles gathers facts easily because facts have meaning for him." — KARL TAYLOR COMPTON

AT THE OUTSET we have to accept the premise that there exists a body of knowledge about managing a business, which understood and applied, augments managerial competency. Will you agree to that? I believe most readers will. Then it follows that a means to gain such understanding and skill in application will be valuable to persons seeking managerial or executive positions.

There is one tried method for accomplishing this — take a management course.

Petroleum management has for years been acutely interested in development of business leadership. It is surprising in view of the rough and tumble early days that so many top oil and gas company officials have found time to participate in management courses.

At first only top executives were enrolled in management development courses. These men were often dubbed "crown princes"; and corporate action sometimes tended too early to exclude other potential management personnel.

In recent years courses in improving executive abilities have been developed for all levels of management in petroleum operations. Today virtually any employee in middle management who wants to, can avail himself of executive courses. Usually the company pays all or part of the expenses. Sometimes, however, they only allow time in which to take the course. But even if you pay the fee yourself it may be worthwhile. You may find that you prepare for it more carefully and select a course particularly to fit your own requirements if you are making some sacrifice for it. At any rate, when you pay expenses you can take some consolation in the fact that you can deduct all expenses for taxes — any traveling to the school, and board and room when there.

Gilbert Chester Jacobus *is Research Professor of Public Administration and director, Army Logistics Research, George Washington University, Washington, D.C. He serves as consultant in executive development to Federal agencies.*

His degrees are: Rutgers University, a BS in civil engineering, 1929; New York University Business Administration, MBA, 1935; and Georgetown University, an LLB in 1950.

Before World War II, Jacobus was with New Jersey Bell Telephone Company. His war service included Intelligence Division of AEF in which he held the rank of colonel.

He has received the Legion of Merit, the Order of the British Empire, and many other awards for his work with U. S. forces.

You can unlock a store of knowledge about how to manage a business. Courses in management are one key to this information.

But wait — you must answer some questions before you enroll:

- How much should I know about such a course before enrolling?
- What can I really expect to get from the course?
- Why do this instead of something else?

WHAT TO KNOW

Before getting into a management course it's a good idea to find out specifically what it offers you in your particular circumstances. Not that you can expect to do anything about the course if you're being ordered to attend! But you can do something about *you*. Understanding what a course has for you, makes possible a *focusing of effort* that pays real dividends. Only *you* can focus your own effort.

Some management courses emphasize the acquiring of knowledge; some are predominantly "skills" courses; some seek principally to stimulate thinking in the field. Most management courses will include some of all three aspects.

For instance, Louisiana State University described a management course as one "developed to give training in the subject mentioned," and proceeded to list in a table, subjects such as Supervision, Economics, Industrial Sociology, Industrial Psychology, Labor Law, Community Re-

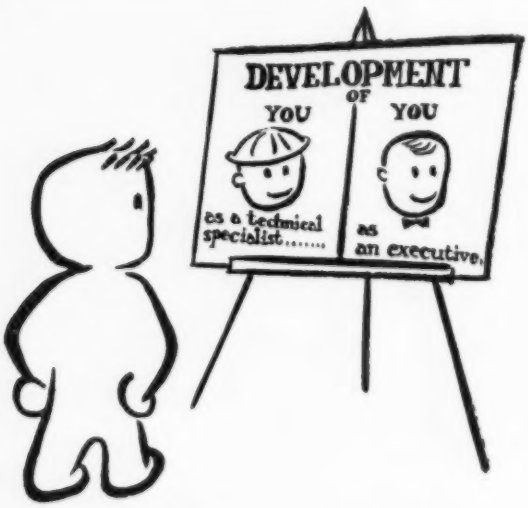
lations.[1] A course such as this, almost on its face, is one that emphasizes the acquisition of knowledge.

Skills training would be found stressed in a course such as the Syracuse University four-week course on controls. In discussing that course the statement was made that: "The Executive Controls Program is designed for members of middle management — particularly those whose responsibilities increasingly call for general management skills as contrasted with those skills solely of the specialist."[2]

This is a course which seeks to increase the skills of managers in using impersonal data such as reports, budgets or organizational plans. The conviction underlying the course is that business controls, systematically and wisely used, will simplify management's job.

For a participant Ohio University's Executive Development program, on the other hand, accents improvement in his ability to think through problems that confront him in his job, "whatever they may be."[3]

Many courses of various educational institutions, management associations, and industrial concerns or govern-



Especially in the petroleum industry you face two roads of development — one as a professional and the other as an executive. You must decide which type management course will help you most.

ment organizations offer various combinations of these three types of learning.

A course directed by the author for Department of the Navy senior engineer executives seeks to balance all three areas. Knowledge important to managing is explored in terms of the level of experience of participants. Managerial skills are developed through case studies and seminar discussions. Capacity to think in terms meaningful to managing is stimulated through case study analyses and provocative reading.

To sum up, before getting into a management course, for your own benefit, you ought to take a hard look at what kind of information is offered and what the prospective course seeks to accomplish for those who enroll.

BENEFITS DERIVED

A question of major significance is: What can you really expect to get from a management course? You get exactly what you seek, assuming only that the course content matches your area of interest and the instructional guidance is reasonably expert.

But so often there is expressed a point of view that "I

✓ Check This List for Managing Abilities

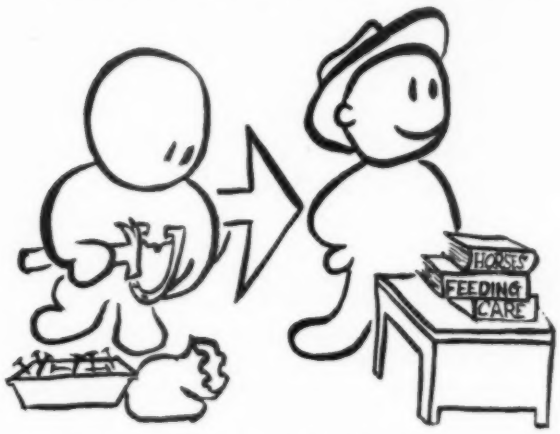
Have you developed a competency to do the following . . .

- ☐ Plan ahead what your group, and individual members of the group, should do.
- ☐ Decide promptly and accurately on the job.
- ☐ Convert decisions into effective action.
- ☐ Set priorities and time schedules that meet the needs of the job.
- ☐ Predict what facilities, supplies, equipment and people (skills as well as numbers of people) are needed for each job to be done by your group.
- ☐ Hold costs within allowable limits.
- ☐ Understand what is needed to give members of your work-group the kind of inner satisfactions they should have.
- ☐ Make clear to members of your work-group what each must accomplish if acceptable results are to be attained.
- ☐ Inspire in members of your work-group a willingness to get jobs done and done well.
- ☐ Judge whether or not results attained by members of your work-group are in fact acceptable in terms of your company's needs and goals.
- ☐ Clarify for each member of your work-group his best relationship with other members and with outsiders (other groups) as necessary.
- ☐ Spot mechanical or personnel difficulties that are developing and take remedial action before serious trouble occurs.
- ☐ Develop understudies for the supervisory job and for any job involving scarce skills.
- ☐ Help members of your work-group to plan for a satisfactory career.
- ☐ Visualize the knowledge and skills you need to qualify for the next job ahead that would mean real progress for you.

don't know enough about managing to know what to look for." Undeniably for the new supervisor, for the aspiring candidate, for the junior executive, there is a bit of dilemma here. Almost without exception, we begin our business careers as technical specialists. The implications of this were pointed out in an earlier article.[4]

Perhaps the chief reason for emphasis on management courses in the oil and gas industries is because so many specialists are directed into administrative channels. This transition is not always easy for the specialist.

Experience indicates management courses have been used



You can't keep a one-track mind and be a manager. Not only must you be able to shoe a horse, you must feed him, exercise him, keep him in good shape.

effectively to prepare such people for administrative duty. When Earl W. Unruh was chief engineer for Sinclair Pipe Line Company he was slated for advancement that required wider background. His company sent him to the Advanced Management Program at Harvard University in 1953. Mr. Unruh says the course provided management theory that helped him — a chemical engineer — to find a different and more effective approach to administrative responsibilities. Within five years Unruh was president of his company and today he says cheerfully "My first job is people."

Another outstanding manager in the industry, Harold Decker, now president of Highland Oil Company, was sent in 1949 to the Advanced Management course.

"I'm not a petroleum engineer any more," he comments, but in his case as in others the background of the specialist is not erased by development of executive qualifications. In the petroleum industry it is generally the best basis for managerial development. As president of a producing company and also as manager of Brown and Root's oil division, Decker's engineering education is perhaps more necessary than administrative education. Understanding the impact upon technical areas of one's management decisions is vitally important.

The point we want to stress is that professional science and engineering careers which extend beyond the specialist level require both technical and management education to buttress experience.

Promotion to a supervisory position, or transfer to a staff activity, creates a different environment, inevitably altering the basis for evaluating your performance. This holds true also as changes occur in advancing through middle management to top executive assignments. Since those fellows upstairs (organizationally speaking) are the people who evaluate our performance, it's wise to try to develop ourselves in ways that produce more of what they look for.

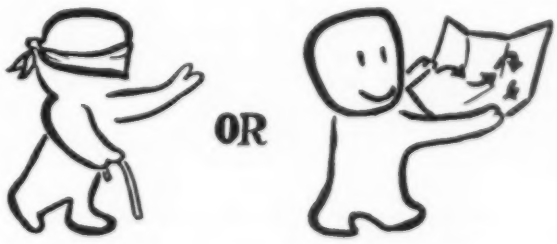
One personnel manager identified three major groupings of factors in ten representative management evaluation plans as follows[5]:

- **KNOW HOW**
  - Requirements of duties
  - Knowledge
  - Planning required
  - Mental application
  - Understanding required
  - Administration
  - Original thinking
  - Creative ability
  - Managerial techniques
- **RESPONSIBILITIES**
  - Initiative
  - Accountability
  - Effect on profits
  - Responsibility for personnel relations
  - Responsibility for policy making
  - Responsibility for policy interpretation
- **RELATIONSHIPS**
  - Supervision exercised
  - Demand for leadership
  - Influence
  - Influence on policy making
  - Influence on methods

Of course, as it stands, lacking interpretation, such a list is of little use to a novice. But doesn't it begin to point the way for understanding what management (the people who dispense or withhold salary increases and promotions) look for when a supervisory or executive position vacancy occurs? A more definitive list of things successful executives do more frequently than relatively unsuccessful executives is published in *Personnel* of November 1955, repeated in *Advanced Management* of September 1958.[6] This is a list of 100 managerial activities; a list some find useful as a check list. It gives some idea of specific knowledge and skills we need to learn.

WHY A MANAGEMENT COURSE?

A variety of approaches exists for learning how to manage. The one most universally encountered, of course, is the "bump your nose" approach. One day the boss calls you in and says, "Next week you will be the head of so-and-so unit. Congratulations!" And that's it. Because of doing "a good job" in the current assignment, a presumption is reached



You may have to try the "bump your nose" approach on a new job but it would be far better to have directions already learned.

that correspondingly "good" performance will occur in the new post. Such a presumption may be valid, but most people find that learning solely through experience is pretty rough sledding.

In many organizations this leads to considerable emphasis upon supervisory counseling. A man ought to be able to turn to his boss for guidance when the going gets rough but this calls for the creation of interpersonal relationships that require much thought and effort on the part of both parties. We have to learn much about people as human beings to do this well. Moreover, harking back to the list of 100 managerial activities mentioned earlier, time runs out for most of us before it's possible through experience or counseling alone to learn all we need to know.

The fact of the matter is that formal courses accelerate the learning process. Subjecting oneself to the discipline demanded by such a course, strengthens the ability to accomplish what is sought. If nothing more, the set pattern established by entry into a course provides a weapon for fending off other demands upon one's time and attention. It provides a rationale for priority.

You have the choice of what you want in management development. Think it over before you select the things you need.

Almost as a matter of course we seek approaches that produce something of practical value. In appraising the impact of one management course, upon its completion we asked senior engineer and research supervisors to answer the question, "Have you changed your techniques of management as a result of this course"? Some of the responses were:

- *"Yes, I believe I have a better understanding of employee-employer relationships."*
- *"Have injected more consideration of planning the accomplishment of the work. Have emphasized that subordinates devote more attention to evaluating the work done by their people. Have attempted to transmit in clear fashion to subordinates the general policies of top management."*
- *"Yes. More participation by supervisors in group discussions."*
- *"Not at this time but I expect to make some changes in the near future. The discussions involving the many facets of management were very enlightening and clarified many phases that were hazy in my mind."*
- *"No. Have, however, re-examined my own performance and methods."*

YOU MAKE THE CHOICE

In the final analysis realistic evaluation of a management course must revolve around your personal plans:

- What do you need to learn to qualify for the position you would like to occupy?
- How soon do you need to learn this?
- On the basis of the best information available, does the course content and the instructional guidance promise to give you what you need?

You must accept major responsibility for charting the path of your own development. You'll find your seniors continually emphasizing that management development is self-development. In line with this point of view, selection of management courses to attend ought to be primarily your choice; a choice consciously, rationally made.

These Should Be Easy Now . . .

1. Why should you examine a management course before enrolling?
2. What questions should you ask yourself before deciding to enter a management course?
3. What kinds of "know-how" are important to a supervisor or executive?
4. What kinds of factors can you expect management to evaluate in relation to supervisory responsibilities?
5. Why should you take a management course instead of trying something else?
6. What is your company's policy in relation to management courses?

Recommended Reading . . .

[1]*James W. Reddock, "LSU Offers Specially Designed Courses", The Petroleum Engineer, August, 1957, page E-16.*

[2]*W. T. Jerome III, "Course Focuses on Controls", The Petroleum Engineer, May, 1958, page E-7.*

[3]*E. T. Hellenbrandt, "Use Case Discussion Technique", The Petroleum Engineer, May, 1958, page C-43.*

[4]*Gilbert C. Jacobus, "Is Management for the Specialist?" The Petroleum Engineer, October, 1956.*

[5]*Robert E. Sibson, "Plan For Management Salary Administration", Harvard Business Review, November-December, 1956, page 108.*

[6]*George W. Bricker, Jr., "The Individual's Program For Self-Development", September 1958, page 5.*

[7]*Calkins, R. D., "Objectives of Management for Supervisors", Harvard Business Review, October, 1946, page 46.*

[8]*Dale, Ernest, "The Development of the Foreman in Management", Research Report No. 7, American Management Association, New York, 1945.*

[9]*Gardner, Burleigh B., "What Makes Successful and Unsuccessful Executives?", Advanced Management, Volume 13, 1948, pp. 116-125, Society for the Advancement of Management, New York.*

[10]*Halsey, George D., "Selecting and Developing First-Line Supervisors", Harper & Bros., 1955.*

[11]*Pearse, Robert F., "Developing Engineers Into Executives", Mechanical Engineering, September, 1953.*

[12]*Pfiffner, John M., "The Effective Supervisor, An Organization Research Study", Personnel, American Management Association, New York, May, 1955.*

[13]*Riegel, John W., "Executive Development", University of Michigan Press, 1952.*

Examining a computer run. Dr. L. J. Peters, vice president, Gulf Research & Development (standing) has given the 704 computer a problem to solve. He is discussing the results with Dr. E. B. Weinberger, head of Computational Analysis Section at Harmarville. They are at the control console of the machine recently installed. The maze of wires in rear is the arithmetic unit of Gulf's tenth and largest computer.

Gulf Opens Computer Center at Labs

New uses of electronic computers listed from developing oil-finding techniques to solving management problems

GULF OIL CORPORATION has opened a new two-story building wing for electronic data processing equipment at its Harmarville, Pennsylvania, main research laboratories. The recently completed project included installation of the company's biggest electronic computer, one of the largest commercially available for scientific applications, the "Type 704," manufactured by International Business Machines Corporation.

The new computer wing was specially designed to utilize large electronic computers and their related equipment. It also includes a number of offices, conference and training rooms.

The new computer will be utilized for a wide-range of research problems of a scientific, engineering, and operational nature. They cover all phases of the company's activities, such as studies in geology and geophysics to improve oil finding techniques, problems in better ways of producing and transporting oil, problems in refining and sales, and general corporate problems involving finances and strategy. The computer can handle as many as 40,000 additions per second; multiply or divide about 5000 times per second. It can perform 100 man-years of complicated calculations in a matter of an hour or two.

It is the tenth computer now being used by Gulf in a constantly growing number of petroleum industry applications for electronic machines.

Gulf's use of electronic computers began in June 1954. From this medium-size computer, operated by three full-time employees, Gulf's company-wide computer activities have grown to include 10 machines and approximately 90 employees. An electronics coordinator, based in Pittsburgh, coordinates their operations.

The staff at Harmarville are no strangers to the IBM 704. The growing complexity of problems arising in petroleum research soon outstripped the capacity of their first machine. Consequently, since 1956, they have been regularly scheduling computing time on the larger equipment, using the facilities of other corporations.

The new computer wing houses about 30 computer specialists and also serves as an advanced computer training school for other Gulf personnel who handle computers in refinery areas like Port Arthur, Texas, and Philadelphia, and in Gulf production centers like Houston, Texas.

Chief task of many assigned to such work is in converting research, engineering and operations problems into "language" the computer can understand. This programming represents a rather specialized occupation.

One of the most important functions of the computation staff consists of training problem sponsors, such as scientists and engineers at the laboratory, to be able to do for themselves a major part of the description of their requirements for machine calculation. This is accomplished by means of newly developed "higher languages" which are convenient for problem description and which the machine can accept and translate into its own basic language.

By means of mathematical models, a pilot refinery can be built on paper and then actual operations simulated within the computer. In this way, new operating and manufacturing procedures which decrease operating costs can be developed, according to Dr. E. B. Weinberger, who heads Gulf's digital computer activities. As an example of projects already demonstrated, Dr. Weinberger lists investigation of catalyst structure, correlation of geologic data, and octane blending as typical examples.

In addition, he said, the direct conversion of many problems in data handling, research and processing to electronic computers has produced immediate and tangible savings. Handling of field exploration problems, preparation of unusual amortization schedules, and analysis of tanker chartering policies are among the many projects to which Gulf has successfully assigned computer time.

The future for computers seems to be a bright one, predicts R. J. Baxter, electronics coordinator, whose salesmanship often must overcome the belief of some that man's work should not be replaced by a machine.

"At Harmarville," explains Baxter, "many projects are five years ahead in their research, simply because some of the manual calculations can be handled as much as 10,000 times faster by computers." ★ ★ ★

Individualism Pays Dividends

Is the individual being swallowed up in unionism? Paternalistic management? Big Brother government?

What kind of society or organization generates imagination and productivity?

Can you run an industrial firm successfully without a union or fringe benefits, without general increases or paid suggestions?

Would an employee rather have higher wages or a pension plan? What produces the vital esprit de corps in working groups?

Here is a man with some answers, but they aren't orthodox.

James M. Rogers

OVER THE YEARS, it has become apparent to me that there are certain industrial management problems that seem to be altogether too general to be ignored. From my own observations and through conversation with men responsible for these operations, certain things stand out as the principal problems that confront those who are responsible for general mobilization of human energy in America.

1. **Individual effort toward productivity is low!** In fact, reduced effort on the part of the people who use the machine has, over the past 10 years, in many cases milked away something in excess of 25 percent of the gains in production that should have been achieved by the new application.

2. **Discipline is a problem** many are reluctant to talk about at first but they have plenty to say when they get going. The extent of this problem often reveals a serious breakdown in the amount of authority left with the people who are responsible for managing the business.

3. **Esprit de corps** is virtually nonexistent in many cases. Pride of workmanship is something we talk about as having existed in "the good old days" but is almost gone today, and the management quite often has grave doubts about loyalty of personnel.

4. **Imagination on ways to improve** the manufacturing process seems to have been relegated to the professional engineer who was hired for that purpose — unless the rank-and-file worker receives a bonus for thinking as well as coming to work.

Occasionally I have come across a plant where an obvious difference existed, and although there were great differences in the details of the personnel and management philosophies, they generally had this one thing in common — either inadvertently or on purpose they had kept a great deal of **responsibility for personal decision with the individual.**

I want to discuss in particular one such organization I saw (the one I later joined).

FIRST, I observed that individual effort and work pace seemed to be quite high. Workmen appeared to be busy and everyone seemed to know what he was doing. A customer who had been at the plant on business told me on the plane as we left town that one of the reasons they buy from this organization was that one had only to go through the plant and watch the people work to know that you get your money's worth from this outfit.

SECOND, from observations and some rather pointed questioning of the management, I found no evidence of the customary disciplinary problems.

THIRD, I sensed a rather strong esprit de corps and what seemed to be a very wholesome rapport between the management people and the rank-and-file workmen. The attitude of the employees regarding their own ability to do a day's work was reflected in a conversation I had with people in town.

When I had left industry two years earlier one reason was the fact that a professional warrior class had sprung up in the plants as a result of labor legislation in the early thirties. It seemed that anyone who thought his job was to increase the effectiveness of people was forced into a battle where he had to abide by the rules of the Marquis of Queensbury but his opponent didn't have any rules at all that governed his actions. One reason I returned to industry was because I saw an opportunity to work where this element did not seem to be present.

All of us must become vitally interested in what it is that produces a high level of imagination, resourcefulness, and loyalty. Too often we limit ourselves to the industrial scene of today to find the answer. Why not try to discover what principles of human relations we might find in other societies where productivity is high? Why not try to see what principles of human relations are missing in societies where productivity is low?

For instance, a study of several primitive societies has led me to believe that people who have been able to keep responsibility "off" the individual and "on" the society rarely develop the imagination and resourcefulness and high level of productivity which we find desirable for civilization.

But those groups in which the individual did assume great responsibility for himself make noteworthy achievements.

Let's examine two such examples in the Western Hemisphere.

The first includes Arctic Circle residents — the Copper Eskimos. There we find the most improverished people in the Hemisphere. As late as 1938 their social arrangement was a form of "collectivism." Vilhjalmur Stefansson

said of these people, "I found them practicing the most complete form of communism I have ever known to exist." Individual responsibility had achieved such limited development that the concept of personal ownership was appreciated by them in only the most limited way. For example, they had no word in the original native language denoting personal possession to correspond to the word "mine."

The group was everything. The individual shunned responsibility. Imagination, on the other hand, appeared nonexistent as it applied to improving the way of life. These people were unchanged from the time they crossed the Bering Strait.

Now — let's examine another group in this Western Hemisphere whose accomplishments as a society are as follows. From 325 BC to 650 AD they achieved:

1. **A written language.**
2. **Unusual knowledge of mathematics** including the symbol to represent what our cipher does, thus enabling them to actually work mathematical problems.
3. **Development of paper** and accumulation of sheets of paper into book form.
4. **Skill of engineering** which, although they had no metals to use, enabled them to quarry huge blocks of stone, move them considerable distances, and build beautiful temples and buildings, roads and aqueducts.
5. **Highly advanced art** form to vie with anything that has existed in any culture on the face of the earth.
6. **Method for computing time,** a calendar far superior to that being used by the white man who discovered them.
7. **Knowledge of astronomy** which made it possible for them to chart the movements of the constellations through the heavens years in advance.
8. **Skill in farming methods** permitting them to produce enough food in 67 days to feed the family for an entire year.

These are the achievements of the Maya Indians who have left such a volume of archaeological treasures that less than one-tenth of them has been uncovered and restored.

What was the difference between these two groups? The real difference is that the Mayas had learned the secret of assuming great personal responsibility. They had developed a sophisticated concept of private ownership of property. They even practiced private ownership of real estate.

What separated the men from the boys in these primitive tribes on this Hemisphere was the fact that the Mayas had learned how to extract from the tribe almost complete responsibility for self and one's family — the fact that the rest of the tribe did not permit them to shift this responsibility onto others.

This one thing seems to be common to all societies where a high level capacity for productivity and imagination is present.

It is the same with an unusual work force of today. Management has constantly kept the employee aware of the fact that his own affairs were up to him as an individual. (This is virtually impossible after the professional warrior moves in.)

Let me give you a few examples in which this matter of individual responsibility is maintained at the Ingersoll Milling Machine Company.

No Labor Union

FIRST big answer is that we have no union, and each employee bargains for himself when it comes to working conditions and wages. This condition is no accident but, of course, it could be famous last words to say that it could never happen at our house.

The management is convinced that present laws, which make the rest of society second class citizens when compared to those who control organized labor movements, are immoral laws.

If an employee has a grievance, it's his responsibility to bring it up and to carry it through the various steps that exist. Making this plan work requires a tremendous amount of education with the supervisory organization and the people in the work force itself.

One thing that helps is the "24-hour rule." Nothing new except perhaps the name. It simply means that any question regarding working conditions, wages, or even the suggestions for improving the manufacturing procedure, must be answered to the employee's satisfaction within 24 hours or it must be carried to the next level of supervision.

Supervisors know that they must anticipate when workers are not content with their answer. When a supervisor senses this, he says to the employee "If you're not satisfied with what I've decided, I'd like to make an appointment for you to talk to my boss about this. Now, don't have any fears about going over my head. The management would be far more critical of me if nobody ever goes over my head than they are when somebody does. They already know I'm not perfect and you'll be doing me a favor if you will talk to my boss about this."

No Pension Plan

SECOND, and I know this is a very radical thing, we have no pension plan and the reason is clear to our employees

James M. Rogers *was for 10 years in industrial personnel work at John Deere Harvester Works, East Moline, Illinois, the last four as personnel manager. His job brought into sharp focus the importance of a better understanding of economics, motivation, and the source and nature of the rights of the individual.*

Rogers appeared in a television debate on a Midwest station and was viewed by Leonard Read, president of the Foundation for Economic Education, who invited him to become his assistant. In this capacity Rogers' chief duties involved lecturing.

In 1955 Rogers joined Ingersoll Milling Machine Company as assistant to its president, Robert M. Gaylord. His work there involves the areas of economics, personnel administration, communications, training, public relations.

— because we have discussed it with them individually many times. In addition to paying the wages that his work demands, we have also added to that rate what other employees receive in the form of pension plans. We have explained that the reason we do this is that all pension plans are simply a form of paying wages, and the management does not believe they know better than the employee the way in which he should save his money for his old age. We even go farther than that — we tell him that as management people we're having a heck of a hard time taking care of our own personal money in such a way that "the evils of inflation or panic do not deplete them."

It is presumptive to us to decide to set aside a part of his wages assuming we know better than he how it ought to be saved. In addition, the law is so arranged that it wouldn't even permit us to do with his money what we would do with our own.

No General Increase

THIRD, we do not have any such thing as a "general increase." This is not to say we never find it necessary to adjust our rates in order to stay where

we think we should be in the labor market. Not too long ago we felt it was necessary to adjust our rates upward about 5 percent, but we did so by evaluating each employee independently. Some of them got much more than 5 percent; some of them less; some of them none at all, and a very small few were told that if they didn't get on the stick, we'd probably decide we could get along without them — but they were all told this individually.

On this particular occasion, it was the works manager and I who had this conference with every person in the factory work force individually — 868 of them. You try it sometime! You'll find that with two people doing it, giving every man a chance for plenty of self-expression, it'll take you about a month and you'll be hoarse. We explained to them that we were adjusting the rates in the plant, we felt their fair share according to the contribution they were making toward the total effort was "X" amount, and then we said something like this, "At such a time, it is always a temptation to introduce some kind of a fringe benefit inasmuch as it seems to be what everybody else is doing — but every time we think about it we're confronted with the same old problem again of concluding that we know how to spend your money better than you do. After struggling with this for a while, we've always come to the same conclusion -- we don't believe we can. Now we'd like you to tell us honestly what you think of our decision?"

Of course, you can say, "Well, naturally they'd take the raise. It's a 'bird in the hand'." In this case, all but 43 said that our conclusion was the only fair one that could be made. We asked them if they would care to discuss with us some of the ways in which they were saving for their own retirement program. We were astounded at the resourcefulness we uncovered.

Continual Interviewing. Personal interviews in our plant with our employees are a constant process. Each foreman receives a reminder quarterly and if he hasn't had an occasion to discuss the employee's progress with him recently, he does so at that time.

Once a year on his anniversary each employee sits down with the personnel manager for the express purpose of discussing with him conditions under which he works or anything else that happens to be on his mind. Such discussions are frequently started by the personnel manager who says, "Okay, just for the fun of it, suppose you were given the responsibility for running this place, what changes would you make?"

As in other cases, questions that arise in this discussion receive an answer within 24 hours.

Changes Previewed. Whenever there is any change in the working conditions, such as a transfer of equipment, the entire plan is discussed with the employees who will be involved before and usually after the change takes place. For example, we recently built a new plant to house our cutter division, which involved some 150 factory and office employees.

When the building was finished, before any equipment had been moved in, employees were shown through the facilities in groups of five or six. After they had seen the new building, they were taken singly, either by the works manager or by me, into a room where a complete model of the factory had been set up, including the machines. There we helped them locate their new working spot and discussed with them the changes that would take place when they moved. We answered all the questions we could and promised to talk with them about the working conditions after the move was consummated.

When they had been in their new spot for a month I talked with every employee in the unit and kept an account of all the suggestions they made to improve the facilities. These, in turn, were discussed with the shop management of the new plant. We gained a great deal in addition to the confidence of the employees.

No Pay for Suggestions

The number of usable suggestions for improving our machines, which comes to us from the rank-and-file workmen, is astounding. We have no paid suggestion system. These people feel that a part of their job is to suggest better ways of producing this equipment. Ideas are our business and to pay extra when somebody has one would be as ridiculous as paying him a bonus for coming to work that morning. But the point I want to make is that imagination is the order of the day. The man who wires the machine is the logical man to come up with some ideas to improve the circuits — and he quite often does. A man of Swiss extraction figured out a way to time an intricate device that left the engineer shaking his head because he hadn't thought of it.

I believe the reason these desirable characteristics exist in this work force is closely related to the fact that these people are not treated as a unit but are constantly made to feel important and responsible as individuals.

What Makes A Man Work?

What I am trying to say is that in industry today we have a tremendous problem of trying to increase the effectiveness of people. I think there is some relation between the extent to which people are encouraged to transfer responsibility for self and family onto the rest of society and the general decline of productivity and resourcefulness. This is true in the industrial community and in our society in general. Responsibility for this trend must be shared by government, paternalistic management, and organized labor units.

You know the arguments in favor of the general leveling devices, which do everything for everyone: Some people cannot bargain for themselves and some people would not save money for medical expenses and for old age. I'm sure these statements are true. I can also see that in all of the societies where a worthwhile culture really did develop, the indolents suffered because responsibility rested upon the individual.

Is it not an appalling thing that in order to arrange for positive protection for the least deserving we have so emasculated the rest of our society that productivity and imagination and resourcefulness has begun to disappear?

This has not come to pass because of the labor movement. This has come to pass because people in industrial management have not fully understood what it is that causes a man to feel like a man and really want to work. We have deprived him, or permitted others to deprive him, of the necessity of making important personal decisions — a degrading situation even for a 16-year-old.

We got into this mess because we didn't bother to figure out in advance the best way to deal with people. This is the crying need of our time — the need for people in all walks of management to take time out from the hurly-burly of immediate decision and to do some soul-searching. Often when people talk about these things, you hear "it's not practical," or "it won't work," or "such thinking is out of date." All such deadly phrases should be forgotten and people should try to figure out what they would believe if the circumstances were ideal. Practices we would recognize to be immoral in other aspects of our living we accept without any great concern in the field of industrial management.

If it were not for the interference of government in the market place, I think that the market itself would take care of the inefficiencies that come about as a result of transferred responsibility.

If you have problems in your plant relative to the general motivation of people, I'd suggest you examine very carefully the extent to which the individual has been kept responsible for his own personal well-being. The record is too clear in the pages of history for us to ignore. ★ ★ ★

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USSR Sees Baku Decline

Offshore wells and deep drilling bring boom in gas-condensate output . . . Tataria, hot spot in "Second Baku," gains top rating

Charles L. Adams

RUSSIA'S FAMED BAKU OIL FIELDS, which 60 years ago produced half of the world's crude, have been written off as a major factor in the Soviet drive to double petroleum output.

The USSR's new Seven-Year Plan for economic growth seeks to increase oil production from 2,260,000 bbl a day in 1958 to 4,700,000 bbl a day in 1965. Of this 2,440,000 bbl a day, Baku is to account for only 100,000 bbl a day increase.

Most of the new production will come from the so-called "Second Baku" area between the Volga River and the Ural Mountains.

In the late 1890's and early 1900's, over 90 percent of Russia's oil flowed from Baku wells. As recently as 1940, the Azerbaijan fields produced 444,000 bbl a day, or 71.5 percent of the Soviet total.

But output losses suffered during World War II are being recouped very slowly and at great cost per barrel. Even if Azerbaijan fields achieve Seven-Year Plan goals, their 1965 crude production will barely reach the 1940 level.

Baku's relative importance in Russia's petroleum industry has declined sharply in the postwar period despite rising output from fields near and beneath the Caspian Sea.

Thus, Azerbaijan's production increased from 230,000 bbl a day in 1945 to 296,000 bbl a day in 1950, 306,000 in 1955, and 312,000 in 1956. At the same time, its share in total Soviet output fell from 59 to 19 percent.

Pravda reports that last year Azerbaijan's oil production reached a postwar peak of roughly 340,000 bbl a day, while proved reserves were up 27 percent over 1952. But the republic's share of total Russian crude output slid to a new low of around 15 percent. By the end of the Seven-Year Plan, Baku will be producing less than 10 percent of the USSR's oil.

Most of Azerbaijan's hoped-for oil production gains will come from the offshore Caspian fields, where output is scheduled to "almost double" during the next seven years, and from the Kura River lowlands southwest of the Apsheron Peninsula. About 30 percent of the 9.8 million ft of exploratory drilling planned for Azerbaijan in the 1959-1965 period will be offshore.

Erection of derrick at Azerbaijan's booming Karadag gas and condensate field at the southwestern base of Apsheron Peninsula illustrates "new, fast techniques developed by Baku engineers."

Although "super-deep" drilling to more than 15,000 ft on the Apsheron Peninsula itself has opened some new oil zones, crude production from the old fields around the city of Baku is expected to decline further. On the other hand, gas and condensate output is rising sharply with development of the Karadag field at the peninsula's southwestern base.

Russian economists estimate that Azerbaijan oil is more than three times as expensive as "Second Baku" oil, and costs continue to soar as average completion depths increase.

During 1955, the average monthly production of new wells in the USSR was 6525 bbl and for all wells 1613 bbl. At the same time, average monthly output in Azerbaijan was 2573 bbl for new wells and 780 bbl for all wells.

From 1946 through 1954, 30 percent of Russia's capital outlay for oil production was in Azerbaijan, which accounted for only 9.4 percent of the nation's output gain. Tataria was responsible for 22 percent of the USSR's output gain during the period while requiring only 6.6 percent of the total capital expense.

In 1955, Azerbaijan utilized over 44 percent of Russia's oil workers to produce less than 22 percent of the nation's crude. Tataria during the same year provided 19 percent of all Soviet crude with only 5.4 percent of the workers. ★ ★ ★

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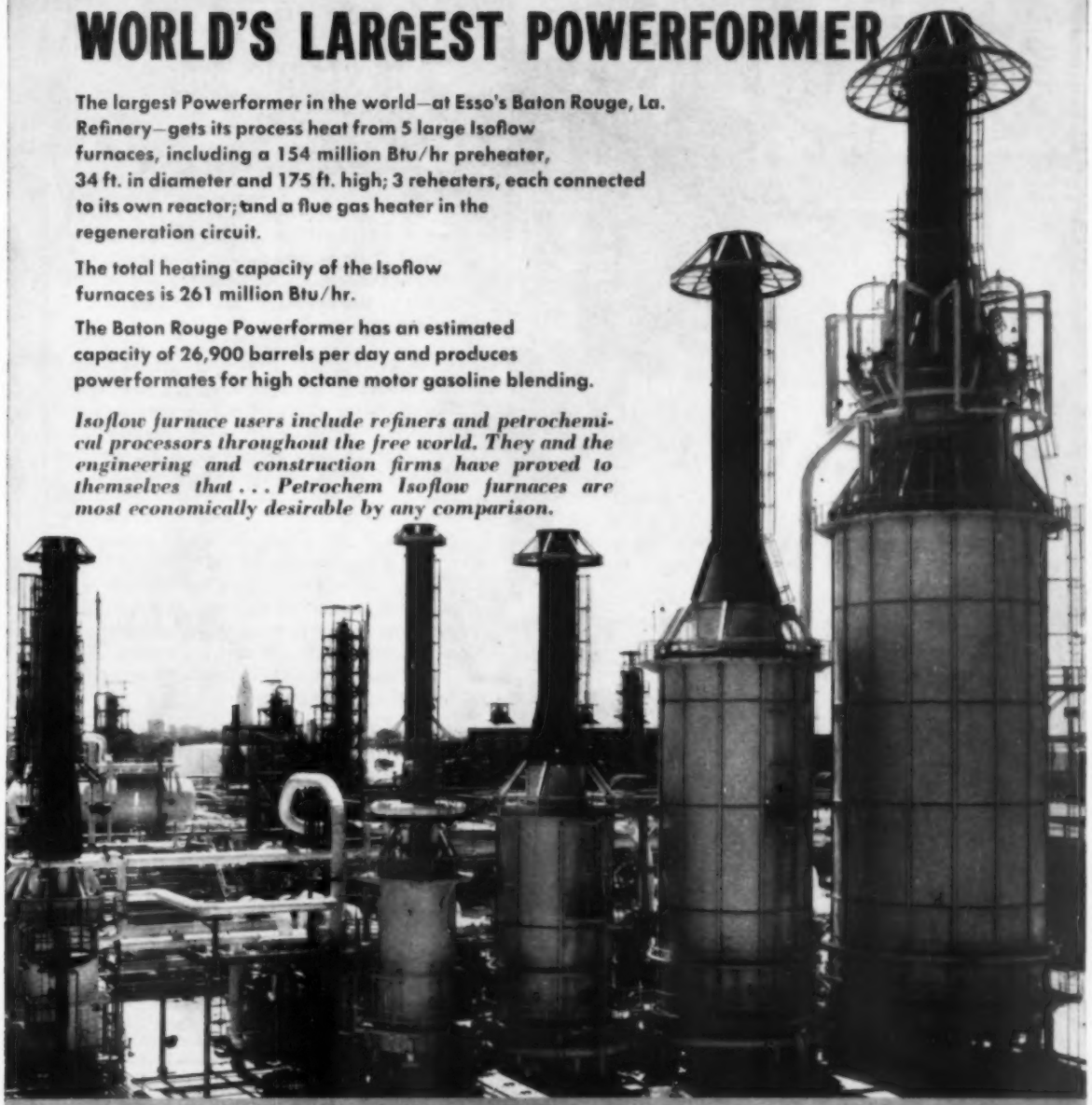

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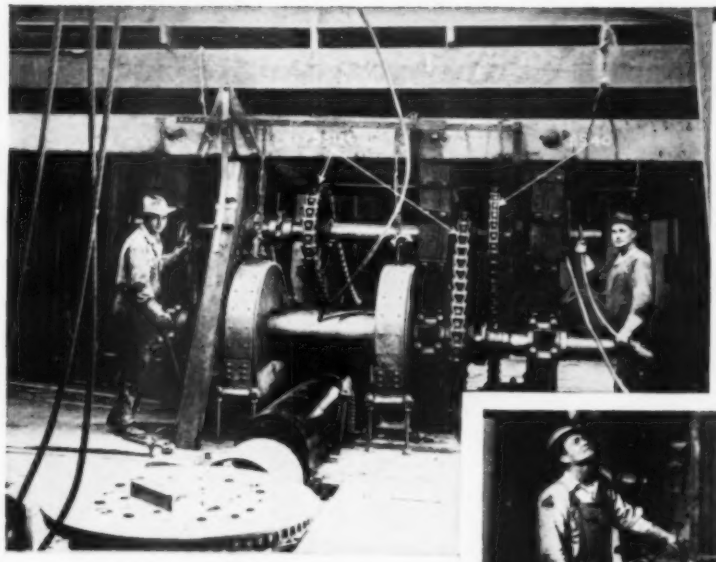

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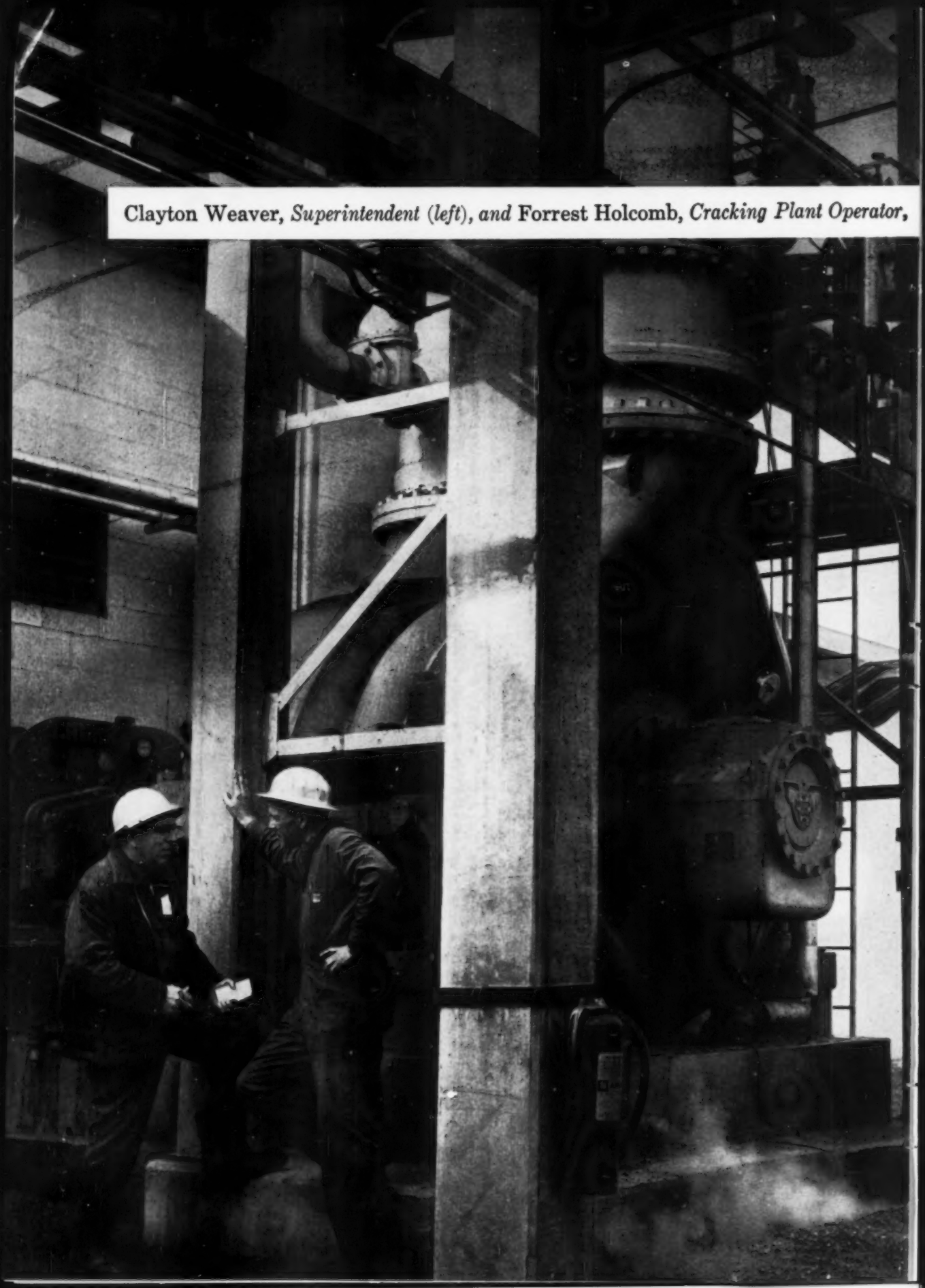

Clayton Weaver, *Superintendent (left), and* Forrest Holcomb, *Cracking Plant Operator,*

Leonard Refineries, discuss function of air supply in catalytic cracking and...

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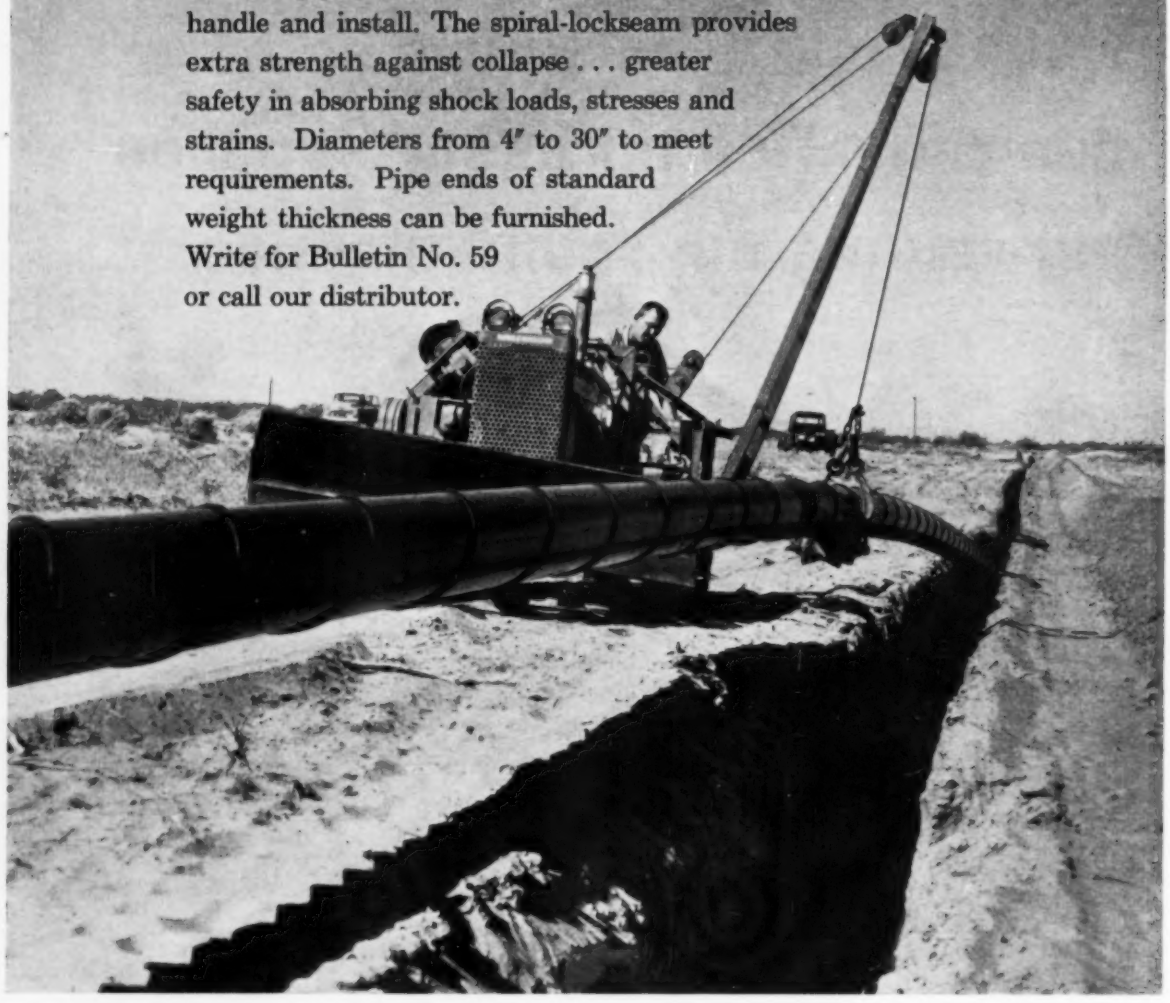

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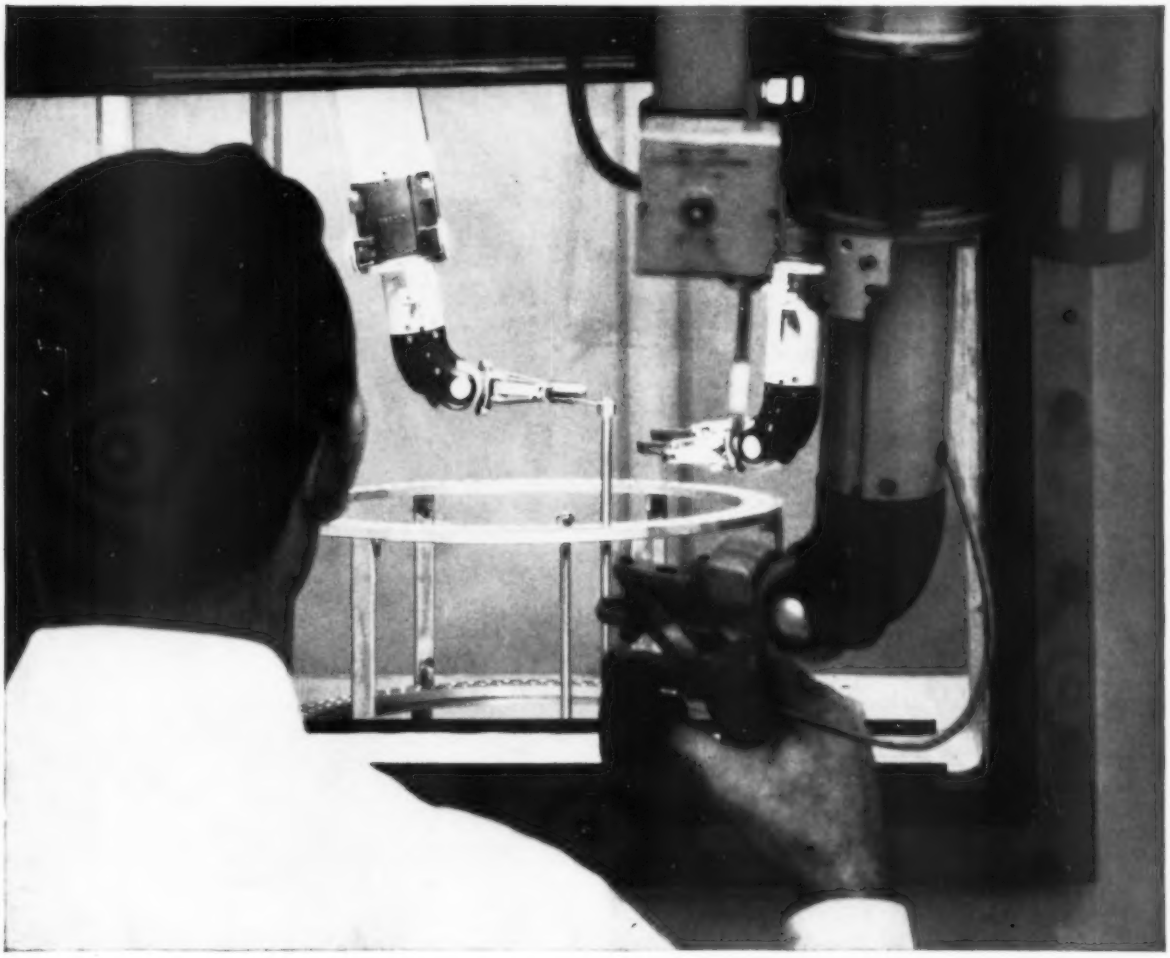

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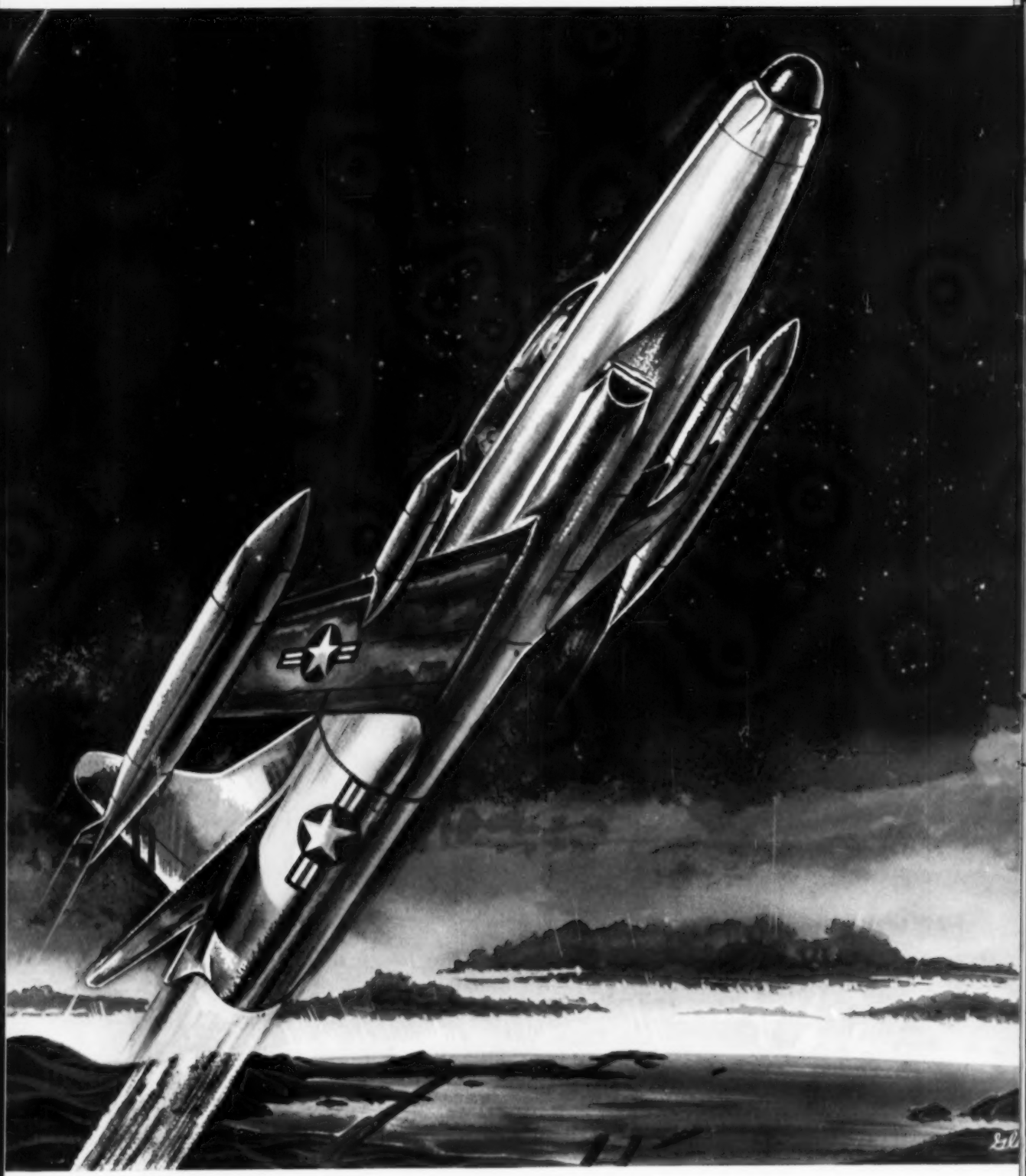

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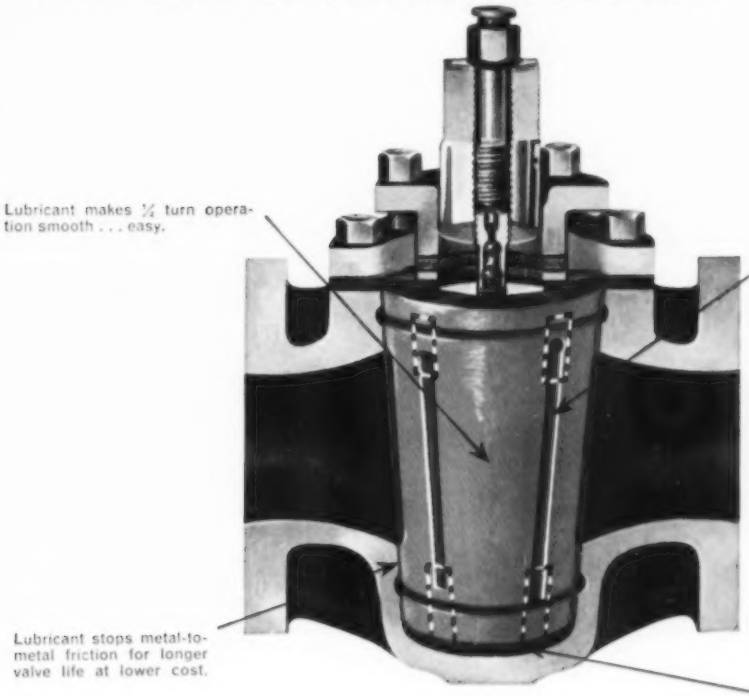
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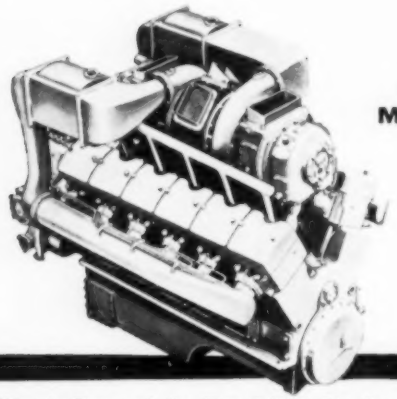

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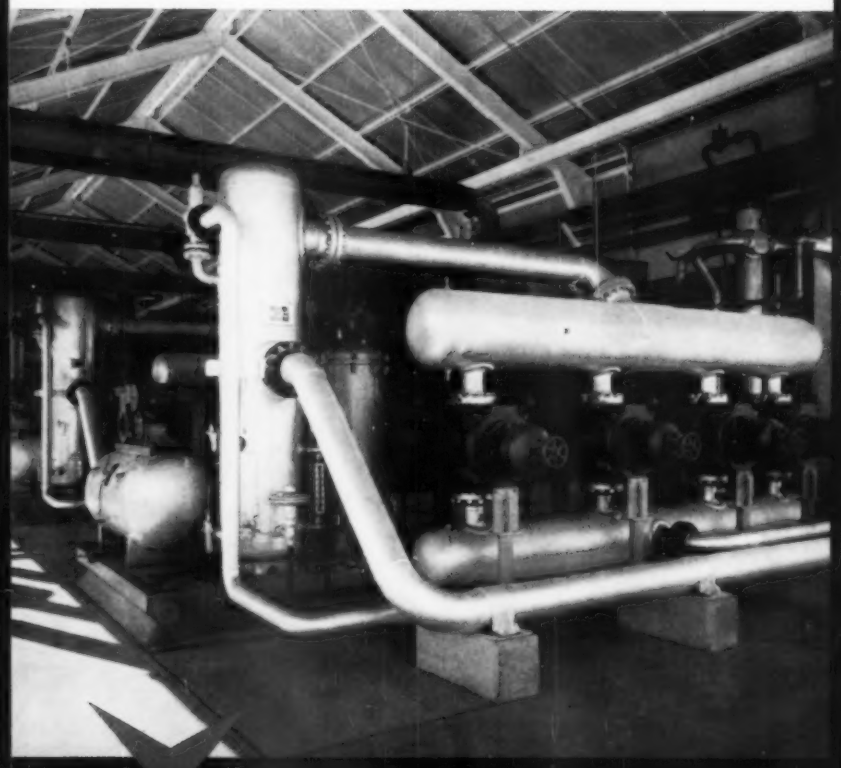

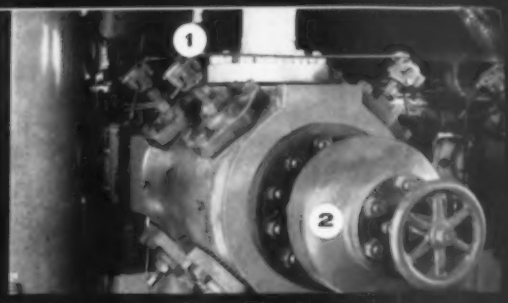

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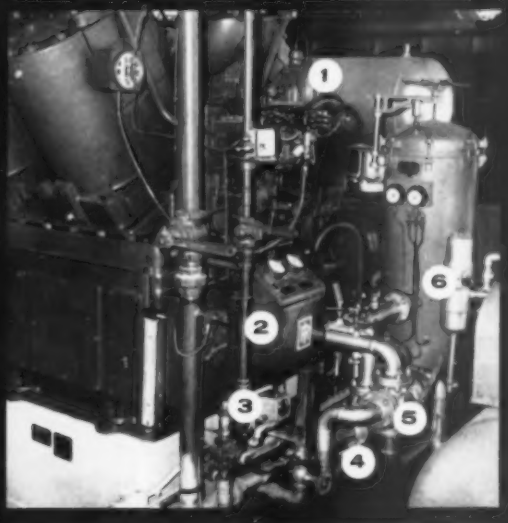

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PHILOSOPHY OF MANAGEMENT PUT INTO PRACTICE

Price of achievement is keystone of good management, says author, and this vital piece for building is found by:

1. **Understanding objectives**
2. **Delegating authority**
3. **Succeeding or quitting**
4. **Playing it straight**

Ben D. Mills

EFFORTS in the field of management are of increasing importance if we are to keep pace with the fast-moving world around us. Let's take a brief look at a subject that is, in my opinion, the most important single element in business today: *The philosophy of management.*

When I mention "philosophy" I want to be certain you understand that I am not talking about the direct management or procedural aspects. I am sure it is fatal to try to transfer a set of procedures from one problem to another. They just never fit. But the philosophy —the underlying motivation—is, in my opinion, transferable.

There is really nothing new in the basic elements of the philosophy. You will find them, I suppose, in the first few pages of most competent writings on management.

It appears, however, that while we give lip service and understanding to these fundamentals, in fact we rarely practice them. And it's in their practice that tremendous results can be achieved.

To set the stage for the elements of the philosophy, it would be well to cover very quickly a bit of background, going back perhaps to the early part of this century. At that time the management scene was typified by the strong individual manager—the "boss" who ran a one-man kind of show. He started the business, directed it himself, and was personally familiar with almost every operation that was associated with it. He was looked upon with favor when he said, "I'll never ask an employee to do anything I can't do myself."

The man who starts out today with a management philosophy like that had better get out of the management field, because he is doomed. He never will be able to accomplish much, because if he waits until he is an expert in every aspect of the business, he will be past retirement age long before he is ready to begin.

The management scene has changed considerably in the last 50 years. It is more complicated. It requires specialization. Also, we must get the most out of the natural resources of the country. So it has taken on a social requirement.

> *When the nation entrusts to a manager a portion of the natural resources of the country, it is his moral obligation to realize a return on the investment the nation has made in him.*
>
> *This is beyond the profit motive, which, of course, is a fairly strong influence in itself.*

Now, these obligations and responsibilities are forcing changes in our management patterns. As time goes on, we are witnessing the growth of a completely new concept of management. It is developing new types of people, and new sets of rules. It is bringing all of our enterprises to new levels of efficiency.

The theory of it is familiar. The practice, I believe, is something we are learning.

What are the elements of this philosophy?

Pride of Achievement Is Key

Keystone of this philosophy is the conviction that the strongest motivating force which exists in the human being is "pride of achievement." This bars, of course, the animal instinct of self-preservation, since circumstances under which this instinct is applicable are inappropriate to this discussion.

I refer to that pride of achievement which fulfills each individual within his own heart, satisfying him in complete privacy that he is contributing something worthwhile. All aspects of this philosophy are aimed at tapping this most powerful motivating force.

1. Management by Objectives

The first element is "*management by objectives*—not management by authority." I'm sure you can say, "Yes, I know that—that's just routine." But is it? I am convinced that a majority of employees still work to please the man who is their superior—not to accomplish what they understand to be their particular piece of the common objective of the entire organization.

I'm sure you're familiar with the story about the three stone cutters. It's a pretty good illustration. A man asked each one of them, "What are you doing?"

Editor's Note: This is a condensation of a paper, "Delegating Authority and Meaning It," given before the American Management Association.

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The first one said, "I am earning a living"—in essence, "I'm working for a paycheck."

The second man said, "Im doing the best job of stone cutting I know how to do." He had a basis for pride in what he was doing.

The third man said, "I am building a cathedral."

The third man knew that the stone cutting, as such, was worthless until those stones were put together and the cathedral was formed. A beautiful job of stone cutting, if you just let the stones lie around, serves nobody. The first man is earning a living. But I'm sure you'll recognize that if everybody worked solely to earn a living, we wouldn't have any cathedrals, and there wouldn't be any money with which to pay the men who are working for a paycheck.

It is the cathedral builders that I believe come close to illustrating what I mean by management by objectives.

Of course, you will recognize immediately that a clear *understanding* of the objectives in the mind of every individual is an absolute essential. It's impossible for an individual to identify himself with the accomplishment of the objective of the enterprise if he doesn't understand that objective. And if he has no personal identification with the objective, he has no basis for personal pride of achievement.

One example that I think illustrates this point very well can be found in the field of engineering. I've talked with some of our engineers and I've found them to be a very dedicated group of men. But I was a little surprised at what some of them were dedicated to. They were *dedicated to engineering.*

I'll never forget some of the shocked expressions when I said, "Let me define your job for you. Unless you engineer a product that can be manufactured and sold at a profit, you have failed completely in the job of engineering. It matters not that you engineer the most beautiful piece of machinery in this world. If it cannot be manufactured and sold in a manner that represents sufficient value to the public that they will buy it in volume—then please put it in the wastebasket and let's get on with the business."

The engineers got the idea. I must admit it took a little while for them to get used to it. But budgetary controls no longer are looked upon by those fellows as the bane of their existence, something to defend against. They no longer stand behind the curtain of "the technical aspects of the business" and "the management couldn't understand that. They're not engineers. How could they be expected to understand it?"

Here's the framework that was established: "As the manager, I will provide the policies within which we will work, and you fellows engineer the produet; but engineer it so we can make a profit on it. Don't engineer it because you take great pride in that piece of the job you have to do. If you will put your concept and mine together, I won't have to bother you about budgetary controls or engineering. You fellows will do it. It's the only way you personally can share in the success of an organization, because it's the only way the organization can succeed."

So the first principle, which I have gone to some lengths to illustrate, is management by objectives, based on a clear understanding of the objectives by each employee and permitting a personal identification with those objectives on the part of each employee. This provides a basis for the individual employee to take personal pride in what he is doing.

Some of you may ask, "Isn't it possible for a man to take pride in his job as a result of pleasing his superior sufficiently that he is the recipient of praise?" I believe the answer to this question is "no." Praise from a superior is merely evidence—and I believe sometimes wholely misleading evidence—that there may be a basis for pride. Praise from a superior may be all right to satisfy appearances to one's fellow employees or one's neighbors, but within the privacy of an individual's own heart, such praise either is known to have real merit or it is neutral at best. Perhaps, even negative.

The Author

Ben D. Mills is vice president of Ford Motor Company and general manager of the M-E-L (Mercury-Edsel-Lincoln) Division. He was named assistant general manager of the M-E-L Division when it was formed in January 1958.

A native of Oklahoma, Mr. Mills attended Oklahoma A & M and later studied law at George Washington University and Southeastern University in Washington, D. C. while employed by the United States Government.

He joined the United States Army Air Force in 1942 and was sent to Harvard Business School where he studied statistical control. Upon discharge from the army in 1946, he joined Ford Motor Company as supervisor of programming, production cost analysis and facilities planning on Ford's Finance Staff. He spent several years in Ford's defense production and Aircraft Engine Division before moving on up to his present post.

2. Delegate Authority

Now, let's move on to the second part of this philosophy. This again you will recognize as routine: *Delegation of authority*. I know everyone of you believes this completely: You must delegate authority commensurate with responsibility.

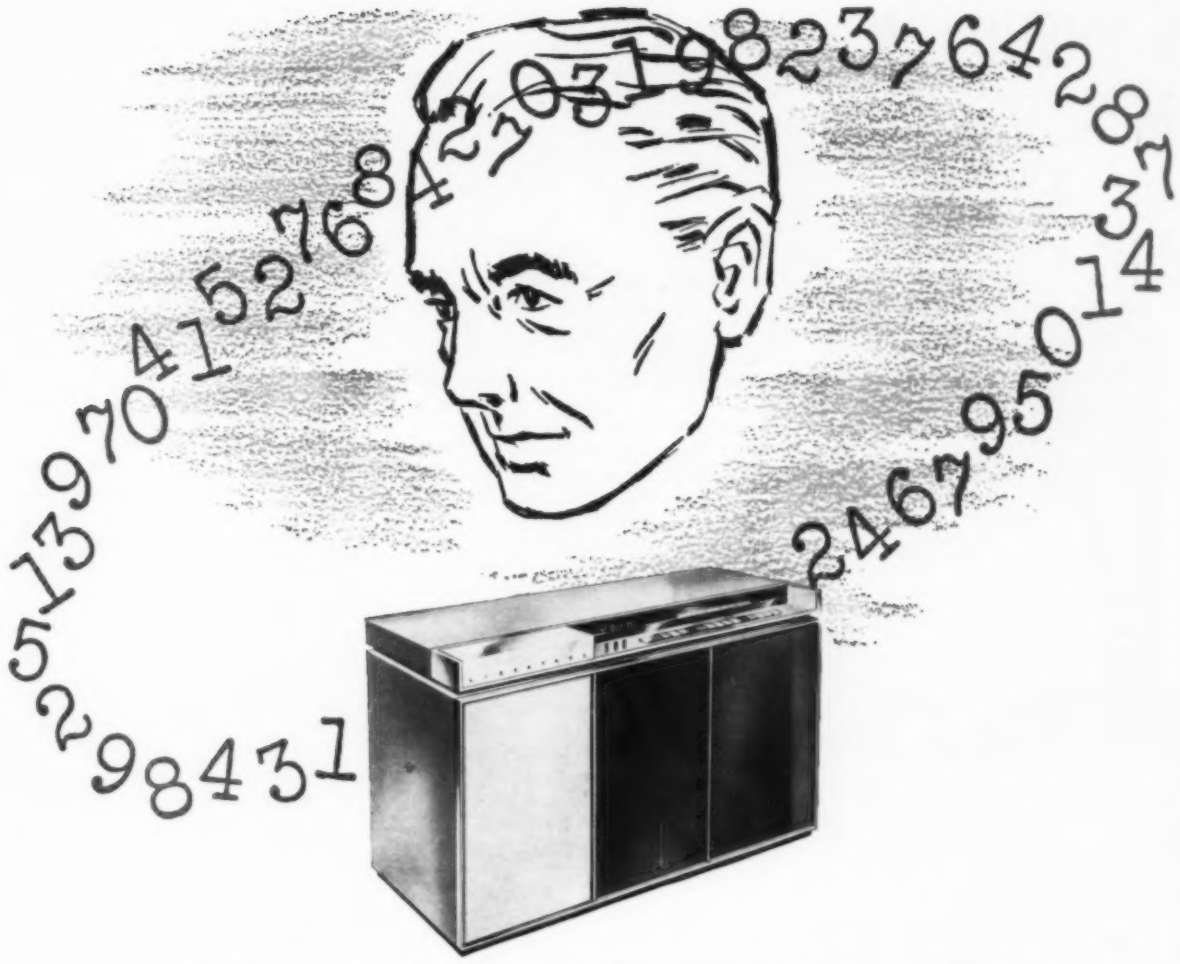
It has been my experience that this principle is not practiced in about 80 percent of the cases with which I have any familiarity. It is just plain not practiced. We assume the selection of people who are competent to do a job. Next, we assume that these competent people understand what their jobs are and why. Now, we must give them the authority to carry out their jobs their way, not ours. After all, if they are competent and they fully understand their jobs, what did we hire them for if we won't let them do the job their way?

Getting down to brass tacks, the thing that I believe is violated time after time is that the supervisor or the manager simply cannot keep his fingers out of it. Instead of guiding the activities of his people in terms of the objectives to be accomplished and the policy framework within which operations are to be carried on, he seems to feel obligated to instruct his people in how they should go about accomplishing the assigned job.

By so doing, he assures that his people will turn to him more and more for direction and will exercise their own initiative less and less. In addition, he gradually robs his people of personal identification with the job and robs them of the foundation for the all important pride of achievement.

When I talk about delegation of authority, I am talking about 100 percent delegation, not 75 percent or 99 percent. Lots of people have asked, "Aren't you afraid to delegate authority to that extent?" My answer is at the opposite extreme—"I'm afraid not to."

Of course, people will make mistakes. But the manager, not being superhuman himself, will also make some mistakes. If the price he must pay for close day to day direction and detailed review of the manner in which his employees go about doing their jobs



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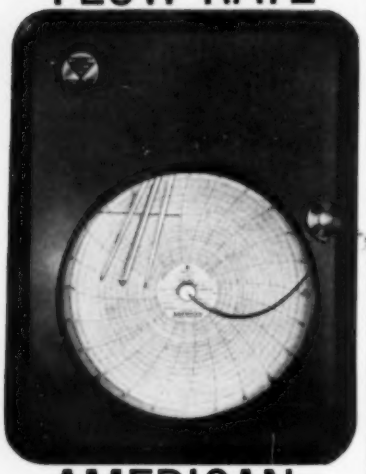

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is the robbing of his organization of its initiative and the gradual killing of individual pride of achievement, then I submit that he has made an extremely poor bargain.

The second element then is 100 percent delegation of authority — letting competent employees who understand their jobs do it their way.

3. Do the Job or Quit

The third element of this philosophy is *accountability*. By accountability, I mean what might be termed a cold blooded demand that a man do his job or get out of it. I have put it in exactly those words. The initial reaction was that it had a threatening tone about it, but a little explanation, I think, altered the threatening tone to something else. This is a promise. It is a guarantee to the competent people in an organization that the manager will remove incompetent people before they ruin the entire result.

Now, you may get the impression that I sit at a desk, call a fellow in, and say "You're fired." Absolutely not. Obviously, in the framework I'm talking about, that would be unthinkable. In such instances, I delay the action recommended by their superiors, sometimes for months. I talk to the individuals, tell them where they are headed if they are not able to step up to the job, and give them every opportunity in the world.

I'm sure you will recognize that failure to do that would be extremely destructive to the rest of the organization. Nobody can do a job if he is afraid he is going to be called in and summarily fired.

You cannot, in my opinion, tap a man's pride of achievement unless the job bites him if he doesn't do it competently. So he must have the rewards if he does do it competently. And in the framework I'm describing, there won't be any question about the rewards being identified with him. He knows he is the one who did it without any interference from anyone else. If it is good, he gets the credit. If it is consistently bad, then he should be relieved of the job in favor of a more competent individual.

4. No Curve Throwing

There is one other element. It is not of the same nature as the three I have mentioned. But it is a string that must, in my opinion, tie the whole fabric together. There must be an *unquestioned integrity* about the manner in which business is done between one individual and another.

The manager must "play 'em the way he sees 'em," without variation. The demands on him for pure objectivity are as great, I believe, as anything he faces. Consistency is an absolute essential to a position of leadership. Nobody can win by throwing curves, or trying to play the angles or cheat. It's got to be all on the table, all the cards face up, all the time.

In addition, the application of this overall philosophy rules out arbitrary decisions. Decisions must be reached by *agreement* on the part of the responsible parties. An arbitrary decision compromises the understanding, the authority, and the accountability of the people involved.

Fit All Group Activity

Extension of these simple precepts into all kinds of human group activities can have real meaning in our future. And I'm talking about every form of group activity, from the family and the raising of children to the formation of governments and the securing of peace in the world. These rules are basic to running a business and launching a satellite.

In this last connection, let me recall for you some of the remarks made by Admiral Hyman Rickover of the U. S. Navy's atomic energy program—the man responsible for the atomic submarine program.

In a recent nationally-televised interview, he was asked for his opinion as to the essentials of any large scientific undertaking.

He had these observations to make:

"Unless you can point your finger at the man who is responsible when something goes wrong, then you have never really had responsibility. Unless you have that type of responsibility, the thing will not get done well."

He continued: "I assign responsibility to individuals. They are fully responsible for their work because everything in this world is done by people or through people and not through organizations with large organizational charts which show full lines and dotted lines, etc."

It comes through pretty clearly. It isn't always in the same choice of words, and it isn't always in the same order or to the same extent. But the same principle applies. Deep in the makeup of every human being—and everything is done by human beings—there is a will to work, but only when certain conditions are satisfied. These conditions constitute human dignity, and are the foundation for the all important pride of achievement.

This can best be assured by giving a man an understanding of the objectives, the authority to carry out his part his own way, and the inescapable accountability for delivering results. ★ ★

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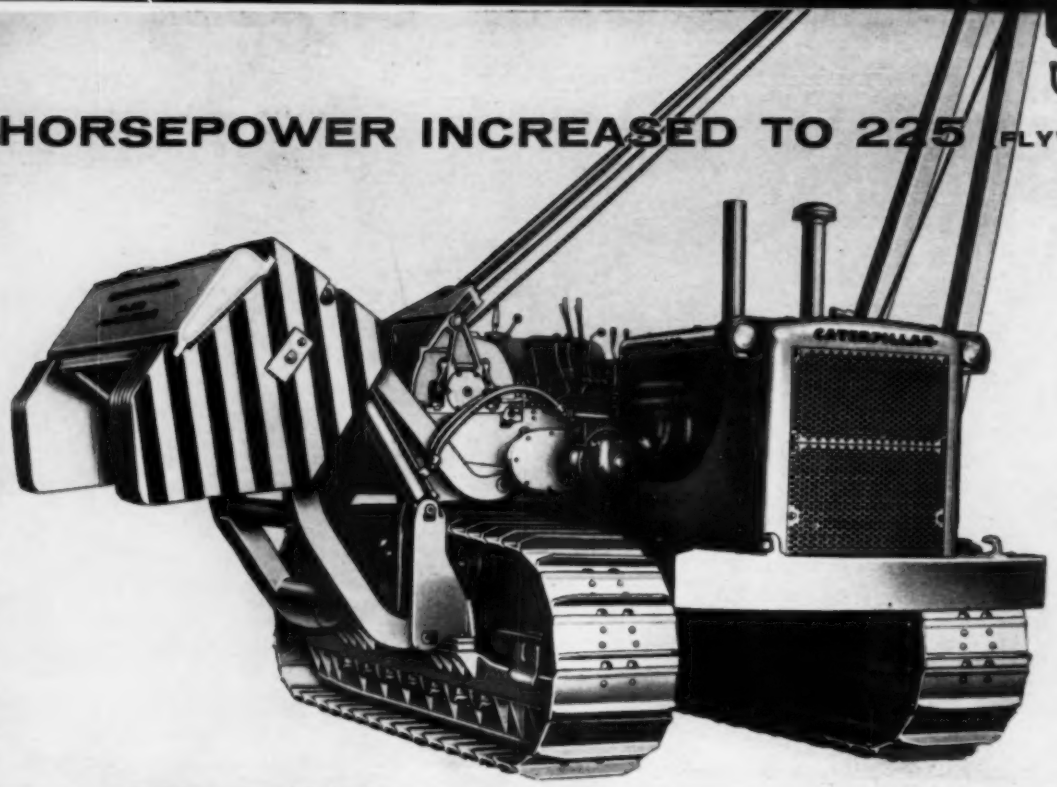

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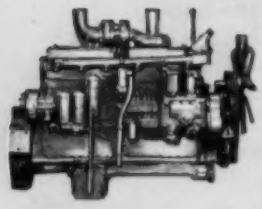

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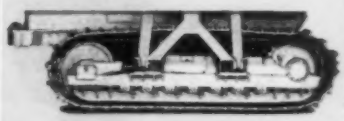

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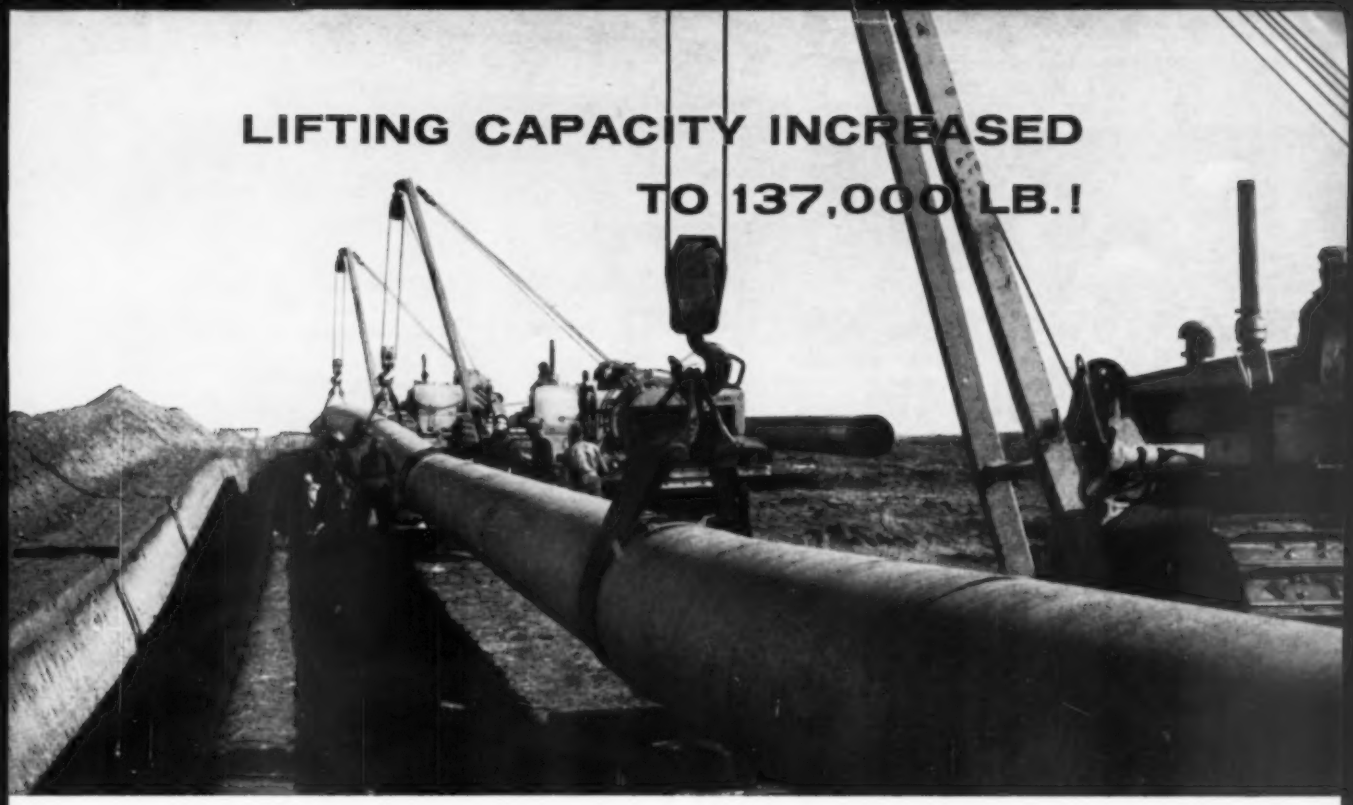

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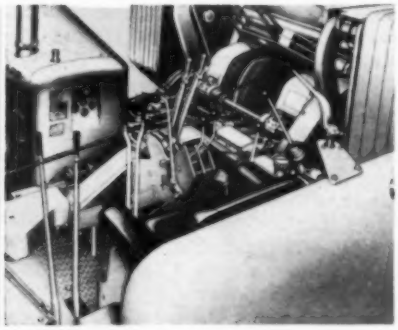

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Eight Industry Leaders to Receive Special Honors on "Old Timers" Day

"Pioneer of Pioneers" and seven "Grand Old Men of the Oil Industry" selected throughout country for traditional ceremony May 17th at Tulsa Oil Show

W. L. Connelly
Pioneer of Pioneers

NOTED for long and outstanding service to the oil industry, eight pioneer oil men will receive special awards during the International Petroleum Exposition this month.

William L. Connelly, Tulsa, one of the best known oil figures in the nation and one of the founders of Sinclair Oil & Refining Corporation, was named "Pioneer of Pioneers."

Sharing the spotlight with Connelly are seven "Grand Old Men of the Oil Industry," each representing a division of the industry: Edmond C. Breene, Oil City, Pennsylvania; William A. Cassidy, Bayonne, New Jersey; Edward I. Hanlon, Frank J. Hinderliter, and Wiley B. Hissom, Tulsa, Oklahoma; Frank H. Lerch, New York; and S. Miller Williams, Robinson, Illinois.

William J. Sherry heads the IPE "Old Timers" Committee that made the selections from nominations received from throughout the oil industry.

Connelly, oil's "Pioneer of Pioneers," has worked 68 years in the industry and is still active as a special consultant for Sinclair Oil & Gas Company and vice president of Delaware Consolidated Oil Corporation. Born in Cleveland in 1873, he drilled his first producer in Wood County, Ohio, in 1895; became a contractor and producer in Montgomery County, Kansas, in 1903; and became associated with Harry F. Sinclair in 1906.

During his 53 years with Sinclair, Connelly has served as president and vice president of numerous Sinclair affiliates; at one time was in charge of all foreign work for Sinclair companies, spending time abroad; and, after Prairie Oil Company and the Sinclair companies merged in 1932, served as chairman of the board of Sinclair Oil & Gas Company until his resignation in 1950. Connelly was a founder of the Rocky Mountain Oil and Gas Association.

Breene, 81, Grand Old Man of Production, is now serving as chairman of the board of Winona Oil Company of Delaware, which he helped found in 1906. Born near Oil City, Pennsylvania, in 1877, he was first a tool dresser in Ohio, West Virginia, and Pennsylvania, while studying for his law degree. One of Pennsylvania's most prominent oil men and attorneys, he was a founder and first president of the Pennsylvania Grade Crude Oil Association.

E. C. Breene
Production

Cassidy, Grand Old Man of Refining, was born in England in 1866, just seven years after Drake drilled his historic well in Pennsylvania. The 93-year-old pioneer still lives in Bayonne where he got a job trucking at Standard Oil Trust's refinery in 1882, the year the company was formed. He was superintendent of the plant when he retired in 1926. Cassidy served several terms as a member of the city council, traveled in the U. S. and abroad, and wrote an autobiography in 1948.

Hanlon, 78, Grand Old Man of Natural Gasoline, is chairman of the board of National Bank of Tulsa, chairman of Hanlon-Boyle, Inc., and president of Hanlon Oil Company. Born in Steubenville, Ohio, he first drove a glycerine wagon in Sistersville, West Virginia, where he spent his youth. The first of many companies to bear his name was Henaghan & Hanlon, Inc., which was formed at Sistersville early in the century. One of the industry's most coveted awards is named for Hanlon. Each year the Natural Gasoline Association of America presents the Hanlon Award to an individual for outstanding service in the field of natural gasoline.

Hinderliter, 84, Grand Old Man of Supplies and Equipment, founded Hinderliter Tool Company, Tulsa, was president and general manager, and had 99 patents to his credit when he retired in 1946. He was born in Rousville, Pennsylvania, in 1875; at the age of 12 started pumping wells for his father, I. N. Hinderliter, who held two oil-field patents on a tube clamp and a belt coupling; and in 1900 worked in a machine shop in St. Mary, West Virginia, which he later bought, then sold in 1906 to go to work with Oil Well

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Refining

E. I. Hanlon
Natural Gasoline

F. J. Hinderliter
Supplies and Equipment

W. B. Hissom
Drilling

F. H. Lerch
Natural Gas

S. Miller Williams
Pipeline and Transportation

Supply. The company placed him in charge of shops in Oklahoma, where he founded his tool company after World War I. Hinderliter was one of the organizers of the IPE.

Hissom, Grand Old Man of Drilling, was owner and president of Hissom Drilling Company, Midland, Texas, before his retirement, and still serves in an advisory capacity. Born in Millers Run, Ohio, 1893, as a youth he drove an oilfield horse team, carried water on a pipeline, worked as a roustabout and with a casing crew, and as a driller, before moving to Oklahoma and Texas where he drilled with his own cable tools and bought his first rotary rig. He was the first to redrill a rotary hole and alternate breaks on tool joints.

Lerch, 71, Grand Old Man of Natural Gas, was chairman of the board of Consolidated Natural Gas Company before his retirement in 1953. He was born in Easton, Pennsylvania, 1888; received a BS degree in chemistry in 1909; later became associated with Ford, Bacon and Davis, Inc.; joined Interstate Natural Gas Company, Inc., when it was organized by Standard Oil Company (New Jersey) in 1926; and seven years later went to New York as assistant and then administrator of Jersey's natural-gas subsidiaries. He has served as president of Interstate, Mississippi River Fuel Corporation, and Colorado Interstate Gas Company, as well as Consolidated Natural, and was founder and chairman of the board of Institute of Gas Technology.

Williams, Grand Old Man of Pipeline and Transportation, was born in Louisville, Kentucky, in 1887, and, with his brother, David R., founded Williams Brothers Company in Fort Smith, Arkansas, in 1908. The first pipeline venture was a 20-mile, 8-in. line to Fort Smith, and, after the company moved to Tulsa, the work spread over the Mid-Continent area and into Canada and included construction of big-inch gas lines in the 1920's. During World War II, the company's work included the Big Inch lines, Air Force work in Africa, and Navy projects in the Caribbean area. Williams, one of the few honorary members of the Pipeline Contractors Association, retired after the company completed Trans-Arabian pipeline in 1950. * * *

Management Personals

▸ **Paul S. Hedrick,** oil editor of the *Tulsa World* and now oil consultant for the *World,* and **Claude V. Barrow,** oil editor of the *Daily Oklahoman* since 1926, were presented parchment commendations for their contributions to the industry through

P. S. Hedrick

C. V. Barrow

the written word by the Oklahoma Independent Petroleum Association, and are signed by **P. R. Schultz,** president, **E. A. Smith,** vice president, and **John J. Robertson,** secretary of the association. This is part of Oklahoma's celebration of Oil's centennial year.

▸ **Lon C. Hill** and **George G. Matkin** were elected to the board of directors of Delhi-Taylor Oil Corporation.

Ben C. Belt, a Houston oilman, has resigned from the board. Hill is chairman of the board and past president of Central Power and Light Company, Corpus Christi, Texas. Matkin is president of the State National Bank, El Paso, Texas.

▸ Two Bureau of Mines regional directors — **Mark L. Wright** of Albany, Oregon, and **Richard B. Maurer** of San Francisco, California — were presented cash awards in recognition of sustained superior service. Wright has been acting regional director of the Bureau's Region I. Maurer has been acting regional director of the Bureau's Region II since H. C. Miller's death in 1955.

▸ **John N. Boyd** was elected assistant treasurer of Gulf Oil Corporation in charge of records and services. He has been manager-payrolls, benefits, and stock records section of the treasury department, and most recently was appointed secretary of the annuity committee and savings plan committee for the company. **C. W. Lutz** was named director-planning and economics department. He succeeds **P. H. Bohart,** vice president, who was recently designated administrative vice president and coordinator, crude oil department.

▸ **Daniel S. Johnston** was named vice president in charge of production, Signal Oil and Gas Company. It was also reported that all Signal officers and directors were re-elected. Johnston has been a Signal director and general manager of the oil production department since 1956.

▸ **E. C. Babson,** division manager, Union Oil Company of California, Calgary, was elected chairman of the board of governors for the year 1959 of Canadian Petroleum Association. First vice chairman is **C. E. Leach,** general manager, Tidewater Oil Company, Regina. Second vice chairman is **A. O. Detmar,** president and general manager, Mobil Oil of Canada, Ltd., Calgary. Re-elected to the board in addition to Babson and Leach, are: **A. F. Beck,** Canadian Export Gas & Oil Ltd., **J. S. Black,** South Saskatchewan Pipe Line Co., Regina; **R. C. Brown,** Hudson's Bay Oil & Gas Co. Ltd., Calgary; **R. A. Cruickshank,** Canadian Devonian Petroleums Ltd., Regina; **W. C. Howells,** Texaco Canada Ltd., Calgary; **C. O. Nickle,** Conick Petroleums Ltd., Calgary; **D. M. Tyerman,** MacPherson, Leslie & Tyerman, Regina. Newly-elected to the board of governors, in addition to Detmar, are: **V. H. Hunter,** Imperial Oil Limited, Regina; **C. S. Lee,** Western Decalta Petroleum Ltd., Calgary; **W. D. C. Mackenzie,** Imperial Oil Ltd.,Calgary; and **J. B. Webb,** Canadian Oil Companies, Ltd., Calgary.

▸ **Joseph C. Kotarski** was appointed a patent lawyer in Continental Oil Company's patent division, with headquarters at Ponca City.

▸ **Dr. Eduardo Acosta Hermoso** has been named Director of Hydrocarbons in Venezuela by the new president, **Romulo Betancourt.** He replaces **Dr. Gustavo Thery Fombona,** who served in that post since 1943. Dr. Acosta was counselor for petroleum affairs in the Venezuelan Embassy in Washington (See The Petroleum Engineer, June 1958, page E-7, for his speech at TIPRO meeting). Dr. Thery will become a petroleum consultant in Caracas. **Dr. Juan Pablo Perez Alfonzo** was recently chosen Minister of Mines and Hydrocarbons to replace **Dr. Carlos Perez de la Cova.**

▸ **Al F. St. Peter** was employed by Delhi-Taylor Oil Corporation of Dallas as manager of its newest department, industrial relations. He has been personnel manager of a manufacturing plant in South Milwaukee.

▸ **J. Howell Turner** became general manager of employee and public relations to succeed **Dr. William J. McGill,** retired. **Ray O. Traylor,** associate director of employee relations, succeeds Turner as director of employee relations. **F. Roe Weise,** associate director of employee relations, will be appointed to the new position of assistant to the general manager of employee and public relations.

▸ **Roy M. Jenkins,** director and secretary-treasurer of the Washington Oil Corporation in Dallas, Texas, has been appointed Guatemala's consul to Dallas. Since 1944, he has been manager of the foreign department of the Dallas Chamber of Commerce, and is also secretary of the chamber's world trade committee.

▸ **John E. Rohrer** was appointed a trustee of Sun Oil Company's multi-million dollar employee stock purchase program succeeding the late John Blair Moffett. He is manager of the payroll department and a 32-year veteran.

▸ **A. Hamilton (Ham) Mencher** has resigned as field editor of the *Rocky Mountain Oil Reporter.* From offices at 323 Empire Building, Denver 2, Colorado, he plans to offer editorial, information, and advertising services for and to the oil industry.

▸ **Howard S. McCray** was appointed assistant to the president of Texaco, Inc. In February 1958, McCray was elected chairman of the board of directors and chief executive officer of the Texas-Zinc Minerals Corporation, a uranium company jointly owned by Texaco and the New Jersey Zinc Company.

▸ **Charles F. Bedford** of Tulsa, now vice president-production and a director, Pan American Petroleum Corporation, will move to Fort Worth, Texas, as vice president, director and division manager of the North Texas-New Mexico division. Bedford succeeds **John R. Evans,** who becomes general manager of production for Standard Oil Co. (Indiana), in Chicago.

C. F. Bedford

Whitney M. Elias, presently vice president, director and division manager of Pan Am's Texas-Louisiana Gulf Coast

W. M. Elias

G. H. Galloway

division at Houston, Texas, moves to Tulsa, replacing Bedford. **George H. Galloway,** currently vice president, director and division manager of the firm's Canadian division, will move to Tulsa as vice president-exploration and a director.

F. C. Osment

L. C. Ritts Jr.

Frank C. Osment and **L. C. Ritts Jr.,** were elected presidents and directors of Pan American. Osment will become division manager of Canadian division succeeding Galloway. Ritts moves to Houston succeeding Elias.

▸ **Coe J. Rost** has joined the purchasing department of Standard Oil Company (Indiana) as manager of purchasing development. He joined Standard in 1950 as an assistant chemical engineer in the technical service division of the research department at Whiting, Indiana.

▸ **C. L. Burrill,** Standard Oil Company (New Jersey) chief economist, and **H. W. Fisher,** who spent 30 years in the Jersey Standard organization before he became joint managing director of The Iraq Petroleum Company in London, were nominated to the board of directors at Jersey Standard.

▸ **T. F. Scoggins** was named public relations manager of Tidewater Oil Company. For the past ten years Scoggins has been in the Shell Oil Company public relations department with assignments in San Francisco, New Orleans and Los Angeles. Prior to 1949, Scoggins was editor of several magazines published by Home Book Publishers in San Francisco and assistant advertising manager of Lawrence Warehouse Company.

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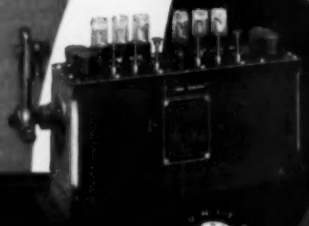

HOUDAILLE

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Specialists in metering pumps and lubricators since 1898

Personals

▸ **Henry H. Beeson** of Dallas was named manager of Magnolia Petroleum Company's natural gas department. He assumed managerial control of Magnolia's natural gas operations, which cover the six states of Texas, Louisiana, New Mexico, Arkansas, Oklahoma and Kansas. He has been assistant manager of the department since 1946.

H. H. Beeson

W. G. Helis Jr.

▸ **William G. Helis Jr.**, New Orleans independent oil operator, was named chairman of the newly-formed petroleum division of the Tulane University development program. Helis also is appointed to membership on the university's national development council, which is composed of 40 civic and business leaders from all parts of the nation. He is chairman of the Louisiana State Mineral board and for many years has been active in civic affairs.

▸ Members of the Desk & Derrick Club of New York City will be greeting women from all over the world when the Fifth World Petroleum Congress convenes in New York at the Coliseum May 30 - June 5, 1959. This is the first time the Congress has been held in the United States, previous Congresses having been in European capitals — London, Paris, The Hague and Rome.

Nine committees are working on the over-all arrangements under an Executive Committee composed of the club president and past presidents, with **Margaret Sweeney**, Sinclair, as chairman and **Edith Snizek**, Rand McNally, as co-chairman. Listed are chairmen and co-chairmen, respectively. *Headquarters:* **Dorothy Watson,** Ethyl. **Sue Mitchell,** Esso; *Interpreters*: **Mary Zitkow,** Petroleum Specialties, **Loretta Helmbrecht,** Texas; *Luncheon*: **Edith Jones,** Commonwealth Gas. **Margaret Cheetham,** Socony Mobil; *Publicity*: **Maree Allstrom,** Socony Mobil. **Regina Weiler,** API; *Registration*: **Gertrude Munafo,** Texaco. **Helen Lambert,** Hartol; *Sightseeing*: **Emily Clark,** Buckeye Pipe Line, **Gertrude King,** Gulf; *Special and Personal Service*: **Muriel Havens,** Tidewater. **Dorothy Metzger,** Texaco; *Theater*: **Alexia Hogan,** Roval Petroleum. **Mae Masters,** Cities Service; *Finance*: **Nell Hagaman,** Shell. **Doris Kendrick,** Richfield. Secretaries are **Lorraine Acker,** American Petrofina, and **Marion Schlotterbeck,** Sinclair Refining.

DEATHS

▸ **M. R. (Army) Armstrong** died March 21 of a heart attack. He was with Ideco, Inc., one of the Dresser Industries.

▸ **Paul D. Wood**, 62, director of industrial relations, Alan Wood Steel Company, died at his home in Norristown, Pennsylvania, after a long illness.

▸ **Charles B. Goddard**, 78, one of the original directors of Humble Oil & Refining Company, died March 11 in a hospital in Temple, Texas.

• News
• People

The Trade PARADE

EXPANDS APPLIED RESEARCH. Calumet & Hecla, Inc. announces a threefold expansion of research facilities which will enable its Wolverine Tube Division to intensify its efforts in the development of materials used in missile, rocket and atomic energy fields. Materials being studied include molybdenum, zirconium, niobium, vanadium, tantalum, titanium and tungsten. Fabrication techniques under study include hot and cold extrusion, high-velocity forming and spin forming.

NEW DISTRIBUTOR. Mid-Continent Supply Co. has been named to distribute the oil field products of the Enardo Manufacturing Co. of Tulsa. By the agreement, Mid-Continent will sell Enardo products in the U. S. and Canada. Mid-Continent stores have been stocked with the complete Enardo line which includes engineered oil field specialties for production, tank vapor control, pipelines and tanks. Some of the latest products of the company include accessory metering equipment, liquid level controls, pressure controls, and volumetric metering equipment.

EXPANDED WAREHOUSE FACILities. Longview, Texas is the site of new and expanded warehouse facilities for the operations of Grove Valve and Regulator Company in the southwestern United States. At the same time, the company closed its Houston, Texas, warehouse and moved its Houston sales headquarters to 3203 Mercer Street in the same city.

INSTALLS DIGITAL COMPUTER. Core Laboratories, Inc., has announced completion of arrangements for the installation of an electronic digital computer, Type 650, in its IMB center, 1410 Dragon Street, Dallas. The data processing facility has been operated by specially trained personnel since 1956. It is presently under the supervision of H. M. Shearin, assisted by Dr. Frank C. Kelton, and Ray Hyman.

APPOINTS NEW YORK REP. The J. E. Lonergan Company, manufacturer of safety and relief valves and pressure gages has named R. C. Bechert Co., 110 E. 42nd Street, New York City, as New York area representatives. Bechert Co. territory includes Northern New Jersey and Metropolitan New York.

FORMAL OPENING. Milwhite Mud Sales Company's new plant in the Algoa-Alvin, Texas area, opened recently. In addition to the most modern, pneumatic type equipment for handling mud, another unique feature is their radio system which covers the entire Gulf Coast from Orange to McAllen, with base stations at Beaumont, Liberty, Houston, Algoa, Eagle Lake, Bay City, Port Lavaca, Alice and Edinburg. All cars of the service engineers and most trucks are radio equipped. Sets are also available for installation on drilling rigs.

TO DISTRIBUTE CLAYTON MARK products. The John G. Bell Company, engineering equipment firm, located at 618 Crocker St., Los Angeles, has been named California representative of Clayton Mark & Company, of Evanston, Illinois.

The Bell firm will distribute Clayton Mark's line of forged steel products, including its Petro, Hydro, Handlebar, and Mark unions, and its check valves and high pressure pipe fittings.

WROUGHT IRON PIPE DISTRIBUtor. Brown Pipe & Supply Company is now distributing new 4-D wrought iron pipe for A. M. Byers Company. Brown Pipe & Supply is marketing the corrosion resistant pipe in cooperation with Byers' division office in Houston, Texas.

AWARDED ATOMIC RESEARCH contract. Clark Bros. Company of Olean, New York, a division of Dresser Industries, has received a contract from the U. S. Army for a research project in the field of atomic power.

Purpose of the research study is to determine the feasibility of an open cycle air turbine system for use in a transportable nuclear power plant capable of producing 750 kw of electrical power. The end result will be a report to the U. S. Army Engineer Research and Development Laboratory at Fort Belvoir, Virginia.

CAMDALE ENTERS PLASTICS field. An oil and gas producer and investment company, Camdale Corporation of New York, purchased controlling interest in Commercial Fibreglas Products, Inc. of Houston, manufacturer of protective fiber glass coatings for the petroleum industry. Crude oil tanks, piping and well-testing equipment were among items listed for development in the fiber glass medium by Glen L. Corcorran of Houston, president and design engineer of Commercial Fibreglas, whose headquarters are in the Niels Esperson Building, Houston.

NEW SALES OFFICE. Ladish Co., Cudahy, Wisconsin, manufacturer of pipe fittings, valves, drop forgings and rolled rings, has announced a new sales office is Dallas, Texas, Room 1010, 211 North Ervay Building. W. F. (Bill) Brockwell and R. O. (Bob) Barlen will represent Ladish in the Dallas area.

SURFACTANTS DISTRIBUTOR. Antara Chemicals, sales division of General Aniline & Film Corporation, New York, has appointed Amsco Solvents & Chemicals Co., 4619 Reading Road, Cincinnati 29, Ohio, as distributors for Igepal CO and CA surfactants. They will provide truck delivery of drum and bulk quantities in Cincinnati, Dayton, Columbus, Springfield and the Southern Ohio area.

NEW ELECTRONIC CENTER. SIE's new 300,000 square foot research, development and manufacturing facility which covers 146 acres at 10201 Westheimer was opened recently in Houston. On this new site, Southwestern Industrial Electronics Co., a division of Dresser Industries, produces electronic instrumentation for a world wide market.

BJ TO BUILD HOLLAND PLANT. Byron Jackson Tools, Inc., a subsidiary of Borg-Warner Corporation, plans to establish a manufacturing plant for BJ Oil Tools in the Netherlands. Known as Byron Jackson N. V., the company will construct a modern manufacturing plant at Etten en Leur, North Brabant Province in south Holland.

Earl M. Rees, formerly export sales manager, was named managing director and European sales manager. G. E. Mullinix will head engineering operations for this new overseas facility. Schedules for start of construction and completion of the plant are to be announced.

EXCAVATOR DISTRIBUTOR. Wheel & Track Equipment, Inc., has been appointed an excavator distributor by Bucyrus-Erie Company, South Milwaukee, Wisconsin. The new distributor's territory includes:

Ohio: Counties of Darke, Preble, Butler, Hamilton, Shelby, Miami, Montgomery, Warren, Clermont, Greene, Clinton, Brown, Highland, Adams, Pike, Scioto, Vinton, Jackson, Lawrence, Athens, Meigs, Gallia.

Indiana: Counties of Franklin, Ripley, Dearborn, Ohio, Switzerland.

Kentucky: Counties of Boone, Campbell, Kenton.

OPENS NEW OFFICE. Graver Tank & Mfg. Company, fabricators and erectors of steel and alloy plate, has opened new sales offices, in Seattle, Washington. Promoted from Graver's East Chicago, Indiana, headquarters to head this office is Richard E. Kimball, district sales manager. New headquarters are at 669 White-Henry-Stuart Building, Seattle 1, Washington. His territory covers Washington and Oregon.

MONTANA AND WYOMING REPREsentative. B-I-F Industries, Inc., of Providence, Rhode Island, recently named Lefler Engineering Sales Company as sales agent for all B-I-F products in the northern half of Wyoming and eastern Montana. These products include all process instrumentation, equipment and systems for positive control of materials in motion.

Two of three self-contained wire line service barges, owned and operated by Welex de Venezuela on Lake Maracaibo, are shown above. The three wire line service units, which are towed by Welex's fleet of tugs, contain a complete electronic tool repair shop, modern crew quarters and a recreation room. The barges, which measure 30 ft by 110 ft, now have skid units mounted near the center of the barge floor.

8-CYL. UV-549
192 max. eng. hp on nat. gas

6-CYL. U-450
112 max. eng. hp on nat. gas

SEE THEM AT THE EXPOSITION!!! Heavy duty pumping engines that cost least to operate

These are two of the seven heavy duty engines you'll want to see in the International Harvester display at the International Petroleum Exposition. The exhibit includes 4, 6, and V-8 cylinder engines that cost less to own and operate over thousands of hours of dependable service.

For lower cost drilling and compressor pump power, check the two new direct-start International diesels on display—the new 385 max. hp, 6-cylinder turbo-charged UDT-817 and the low-cost 95 max. hp 6-cylinder UD-282. Other models in the exhibit set-up of heavy duty extended service engines include the UC-135, UC-221, U-308 and U-450.

International carbureted engines can be equipped with the same maintenance-reducing attachments as shown on the display models: automatic start and stop; Ren exhaust condensor and automatic oil level regulator; heavy duty air cleaner; long-life Cannon spark plugs; rugged Twin Disc PTO; automatic radiator shutter; magneto ignition with platinum points, and an Oildex attachment that removes carbon and foul gases from the engine to promote long life.

If you are unable to attend the exposition, your nearby International Power Unit Distributor or Dealer will give you full details on these seven engines as well as any of 17 other models in his complete oil field power line. Power range is 16.5 to 385 max. hp and the one common feature is: Every International costs least to own and operate.

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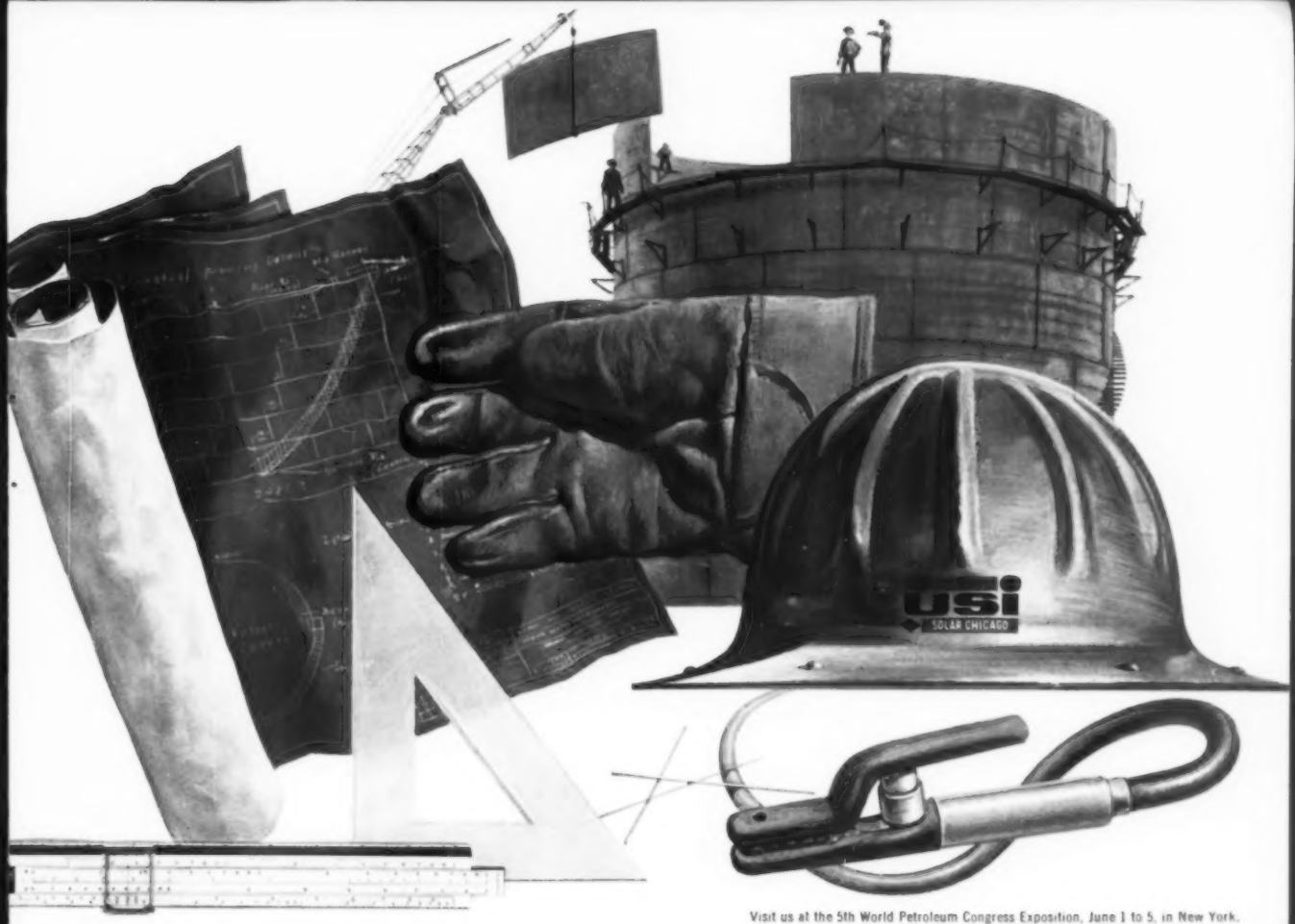
A COMPLETE POWER PACKAGE: Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom-Dump Wagons . . . Crawler and Rubber-Tired Loaders . . . Off-Highway Haulers . . . Diesel and Carbureted Engines . . . Motor Trucks . . . Farm Tractors and Equipment.



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International Oil Show, May 14 to 23, in Tulsa.

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New King-Sized DUMPMASTER Automatically Collects and Hauls Up To 120 cu. yds. of Refuse per Trip

Shown above is the Dempster-Dumpmaster CA30-24DB model which has a capacity of 100 cubic yards of loose refuse material.

Shown above is the CA15-18DB which has a capacity of 72 cubic yards of loose refuse material.

DEMPSTER BROTHERS' Newest Addition Cuts Waste Disposal Costs

The famous DEMPSTER-DUMPMASTER 24 DB now has a big brother in the CA60-30DB model. Like the original Dumpmaster, it automatically handles detachable containers in one through six cubic yard sizes. However, it can pick up a gross load of 6000 pounds as compared to the 24DB's 3000 pound capacity.

Another important difference in capacity—the new model can compact up to 120 cubic yards of loose refuse while the 24DB gets up to 100 cubic yards per trip. Like all Dumpmasters, the new 30DB has clearance arms for safety . . . they never pass the cab windows . . . can't injure the operator.

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BATON ROUGE SALES OFFICE. Fritz W. Glitsch & Sons, Inc., Dallas, manufacturers of fractionation trays and pressure vessels for the petroleum refining and chemical industries, has opened a new sales office at 256 Peachtree Blvd., Baton Rouge, Louisiana. The new office will serve Alabama and Mississippi, the Southern two-thirds of Louisiana, and sections of Northwest Florida. Louis A. Venincasa, formerly located in the Glitsch Dallas office, has been named representative in charge of the new office.

EXPANDS DENVER PLANT. The Heiland Division of Minneapolis-Honeywell Regulator Company has expanded its Denver facilities for the second time in two years. S. A. Keller, Heiland general manager, said that when the expansion program was completed in April the Denver plant contained in excess of 70,000 square feet of engineering, production and administrative facilities. The new addition is used for wiring and testing of the division's industrial recording instruments, including its 36-channel direct-recording Visicorder oscillograph.

SOUTHERN SALES REPRESENTAtives. W. S. Rockwell Company of Fairfield, Connecticut, announced that Rawson & Co., Inc. Houston, Texas, and The Rawson Company, Inc., Baton Rouge, Louisiana, are the new sales representatives on butterfly, slide and special valves in South Texas, Southern Louisiana, and Southern Mississippi area. W. B. Rawson, Robert Houlihan, R. E. Moore and L. F. Washburn are in the Houston offices and at the Baton Rouge office is James H. Simpson, Jr.

FORMATION of a new Oklahoma company, Fox-Texoma Mud Company, as a new division of Magnet Cove Barium Corporation was disclosed by I. W. Hoskins, senior vice president — marketing of Magcobar. The formation followed the purchase by Magcobar of Texoma Mud Company and the mud distribution properties and mud handling equipment of Fox Rig & Lumber Company. Both companies are former independent distributors of Magcobar's oil well drilling mud products in Oklahoma, Texoma with headquarters at Oklahoma City, and Fox with headquarters at Ardmore. Fox Rig & Lumber's activities in the lumber and building supply business will not be affected. The personnel of the new company include the employees of Texoma, the employees of the former Mid-Continent Division of Magcobar, and employees who were associated with the mud supply part of Fox' business.

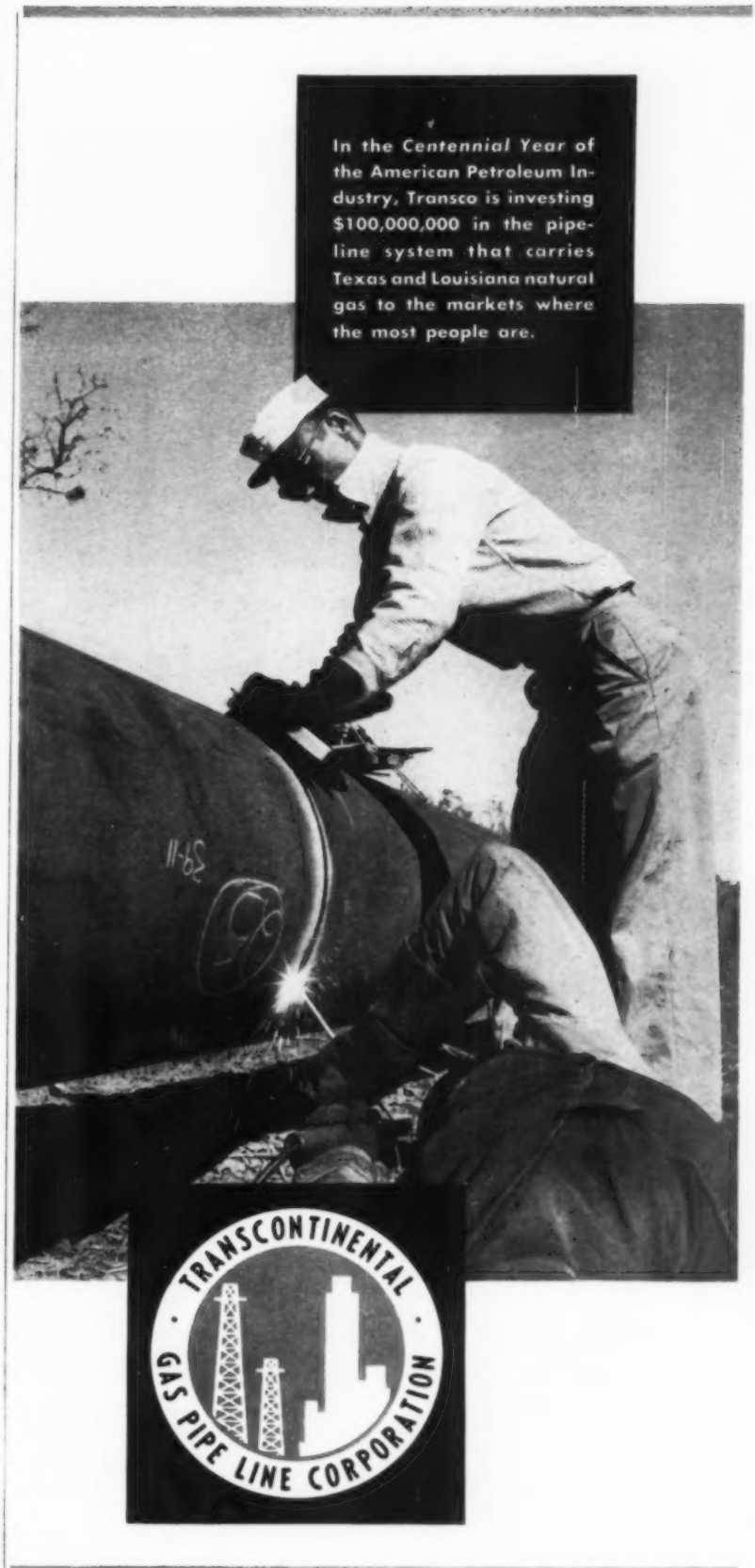
GULF COAST REPRESENTATIVE for Wheatley. Effective March 15 Southern Engine and Pump Company became Gulf Coast sales and service representative for the entire Frank Wheatley piston and plunger pump lines.

▸ **Collins Radio Company.** Oliver J. Greenway was named general manager of Communication Accessories Company, a subsidiary.

▸ **Standard Pipeprotection Inc.** John B. Wilson was elected executive vice president. Lee A. Whitney was elected to the board of directors. He is a vice president of Champlin Oil & Refining Co.

Wilson is the former vice president and treasurer.

▸ **Parsons Company.** R. H. "Dick" Danford was named district representative for the western areas of the U. S. He was formerly an officer and a stockholder in the Standard Machinery Company of San Francisco.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WATER FLOOD PIPE LINES can be protected from corrosive waters.

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WHERE CORROSIVE WATER is causing too frequent water line problems, Cement Mortar Lining is your answer.

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Division of American Pipe and Construction Co.

Trade Parade

▸ **Southwestern Industrial Electronics Co.** Newton E. Armstrong, until recently product manager, control division, was appointed manager, systems development

N. E. Armstrong

J. B. Tate

division of Southwestern Industrial Electronics (a division of Dresser Industries.)

Joseph B. Tate has been named manager, military electronics division. He is responsible for the development of military electronic apparatus and instrumentation for SIE.

▸ **Technical Oil Tool Corporation.** William L. Brannon has been named export representative. For the past 4 years he has been in sales and service work with the Hydril Company.

To represent TOTCO in the Bakersfield-San Joaquin-Northern California area, is John Sowers of Bakersfield. He has been employed by Hughes Tool Co.

▸ **Carrier Corporation.** Frank E. Purcell was named sales manager of packaged equipment for the Unitary Equipment division. Purcell has been sales manager of the national buyer department at Carrier since 1956.

▸ **American Steel and Wire, U. S. Steel.** Edward A. Murray was appointed vice president-sales succeeding Harry M. Francis, who has been elevated to executive vice president of that division. Murray was formerly assistant vice president-sales.

▸ **Oil Well Supply Division,** U. S. Steel. Lewis Y. Poland has transferred from store manager at Medicine Lodge, Kansas, to field representative at the same location.

▸ **Mission Manufacturing Company.** O. K. Ryan has announced his retirement after almost 26 years' service. His most recent assignment was sales representative in the Lubbock area.

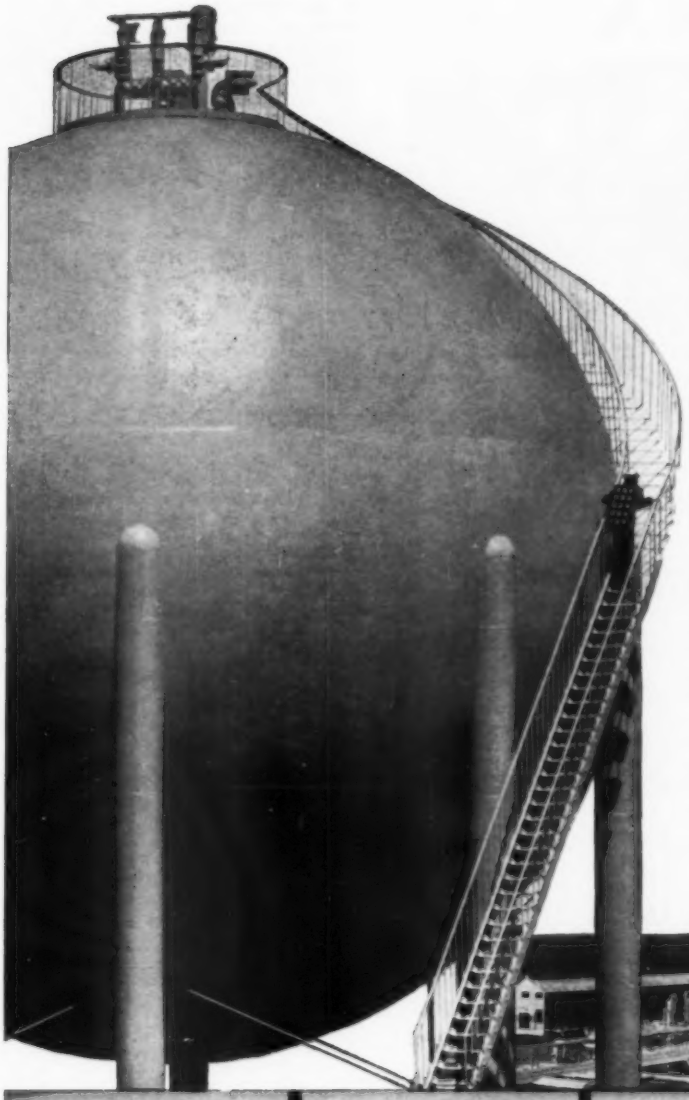
▸ **Dowell.** Joe P. Pavlich is district engineer for Dowell division of The Dow Chemical Company at Houston. He was transferred recently from Hobbs, New Mexico, where he had been a petroleum engineer.

▸ **Fluid Packed Pump Company.** A. Grey Simpson has been promoted to the position of California division manager. For the past 2 years he has been California sales manager.

A. G. Simpson

R. E. Burton

▸ **Koehring Company.** R. E. Burton was promoted president and general manager of its Buffalo-Springfield division at Springfield, Ohio. He was with the Koehring central office staff in Milwaukee as assistant director of marketing.



Tough, colorful, lasting beauty!

Take those pumps and rigs in the oil fields—or those tanks and pipelines in the refineries! Each needs the tough, colorful, lasting beauty that Rust-Oleum provides. If the surface is rusty, Rust-Oleum 769 Damp-Proof Red Primer can be applied *right over the sound rusted surface* after removing rust scale and loose rust. Special Rust-Oleum Oil Field Finishes match the original equipment colors on pumps and rigs – while other long-lasting Rust-Oleum coatings protect costly tanks and pipe lines.

They're specially made for oil field use – tough, flexible, easy-to-use on the spot by brush or spray! They dry to firm, glossy finishes that resist sun, fumes, heat, moisture, weathering, and blowing dust and sand.

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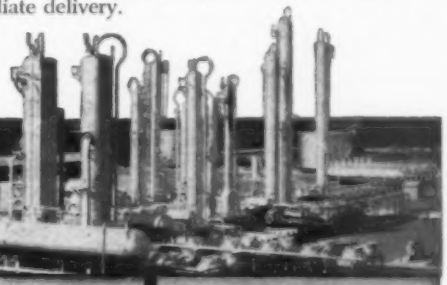

Apply Rust-Oleum 769 Damp-Proof Red Primer directly over sound rusted surfaces.

Follow-up with the Rust-Oleum finish coating in the color of your choice

By brush or spray – the Rust-Oleum system provides tough, colorful, lasting beauty.

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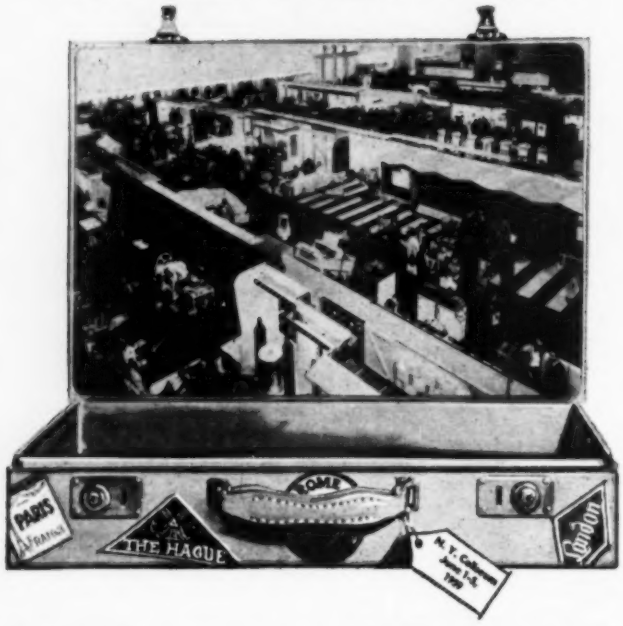

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Trade Parade

▸ **Layne & Bowler, Inc.** C. E. Ponkey of Memphis, Tennessee, was named president. He succeeds W. H. Reeves, who is retiring after serving 52 years in various official capacities for Layne & Bowler but will continue to serve in consulting capacity as a vice president. Ponkey was formerly executive vice president.

C. E. Ponkey

G. P. Oldham

▸ **Barrett Division, Allied Chemical Corporation.** G. P. Oldham was named vice president in charge of marketing. He has been vice president and general sales manager of Gustin-Bacon Company for 5 years.

John C. MacLeod has been named to the newly created post of assistant to the president in charge of operations with headquarters in New York. He was formerly assistant director of operations for Allied's Solvay Process Division.

▸ **Blaw-Knox Company.** E. P. Additon was appointed manager, contracts and sales promotion, chemical plants division. He is from the division's offices in Haddon Heights, New Jersey, where he served as district sales engineer.

E. P. Additon

F. L. Magoon

▸ **Garrett Oil Tools,** division of U. S. Industries, Inc. Fred L. Magoon was named administrative engineer in charge of research projects in the firm's home office and plant at Longview, Texas. He was with Fibercast Company, division of Youngstown Sheet and Tube Company, serving as chief engineer for 8 years.

▸ **H. U. Garrett** of Longview, Texas, acquired the assets of McFarland Manufacturing Corporation of Houston on February 17. The firm was founded in 1948 and manufactures air, gas and fluid-operated chemical injectors, transfer pumps, proportioners and hydrostatic testing units which are distributed to the oil, refining, processing and petro-chemical industries. Garrett is president and Clarke A. Polk continues as vice president; Lyal W. Hetrick as secretary-treasurer.

H. U. Garrett

C. A. Polk

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Westinghouse Electric Corporation. K. M. Patterson is appointed manager of headquarters sales departments for the apparatus division in East Pittsburgh, Pennsylvania. Succeeding Patterson in his former position as manager of the division's industrial sales department is C. E. Hammond, who was formerly assistant manager for the division's South Pacific district in Los Angeles.

Security Engineering Division. Ralph Hughes was named manager of manufacturing for both the Dallas, Texas, and Whittier, California, manufacturing operations of Security, one of the Dresser In-

Ralph Hughes

W. J. Neilson

dustries. Previously Hughes was operations manager of the Whittier plant.

William J. Neilson was appointed new operations manager for the Whittier manufacturing plant of Security Engineering. Previously chief product engineer, Neilson has been associated in a design position with Security for more than 15 years.

Petrolite Corporation. R. T. Thompson, sales engineer for Tretolite Company division at Houston, Texas, has retired.

The National Supply Company. George B. Cushing was elected a vice president. He was formerly director of public relations and advertising.

G. B. Cushing

James Mills

BJ Electronics Borg-Warner Corp. James Mills was promoted contract sales manager with headquarters at Washington, D.C. Mills was formerly eastern military and industrial products representative for the firm.

Magnet Cove Barium Corporation. R. B. (Buddy) Hyde Jr., was promoted from chief service engineer of the drilling mud

R. B. Hyde Jr.

J. N. McCaskill

department to the newly created position of export sales manager of the foreign operations department. Succeeding Hyde is James N. McCaskill, a member of Magcobar's staff service engineering group for the past two years.

Halliburton Oil Well Cementing Company. Elmer Lacy, former division manager at Wichita, Kansas, has retired after

almost 37 years' service. Hubert Northcutt, formerly the division manager at Abilene, Texas, is replacing him. Lacy is circling his effective retirement date with Northcutt looking on.

Jones & Laughlin Supply Division. Samuel M. Harris Jr., was assigned as salesman at Sterling, Colorado and Phillip M. Spears, assigned as salesman at Hobbs, New Mexico, and are graduates of J&L's sales training program.

S. M. Harris Jr.

P. M. Spears

Motorola, Inc. Joseph A. White has been named zone manager for Motorola Communications & Electronics, Inc., Chicago, in southeastern Louisiana. He had been a sales staff member in Motorola's southern area Dallas offices.

Robert F. Davis was named manager, two-way radio sales, of a 13-state Midwest area for sales and service subsidiary of Motorola, Inc. Taking Davis' former position of regional manager in Northern Illinois, Northeastern Indiana, Eastern Wisconsin and Michigan's Upper Peninsula is Eric Goleas.

Baroid Division, National Lead Company. Norman K. Tschirley was named technical sales director of Baroid-Maffei S.p.A. Baroid-Maffei is a new company organized to supply drilling mud products to the oil industry in the Mediterranean and Persian Gulf areas. Mine, plant, and mill facilities of the company are located

N. K. Tschirley

G. B. Coale

on the island of Sardinia and Tschirley will headquarter at Baroid-Maffei home offices in Milan, Italy.

George B. Coale, general manager, was elected to the board of directors of National Lead Company. He is also a vice president of National Lead and has been general manager of Baroid Division.

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Trade Parade

▸ **Otis Engineering Corp.** Dick M. Koons and Malcolm B. Roach were appointed vice-presidents. Koons is director of the

D. M. Koons

M. B. Roach

research and development department for the company, joined Otis a year ago. Roach serves as general sales manager.

▸ **Youngstown Sheet and Tube Company.** Robert C. Bryan, formerly of Pittsburgh, has joined the staff of the comptroller as manager of a new department of systems and procedures. Bryan joins the company after having been employed by Blaw-Knox Co. and Jones & Laughlin Steel Corporation in Pittsburgh.

▸ **Allis-Chalmers Manufacturing Company.** Stanley S. Scott was assigned as a sales representative to the Houston district of Allis-Chalmers Industries Group, formerly serving as an application engineer in the compressor department. Malcolm S. Jones was named manager of the El Paso district. He had been a sales representative in the Denver district since 1951.

Bruce C. Halsted was appointed manager of the Richmond district succeeding J. M. Mathews, resigned. Halsted had been a sales representative in the Richmond district since 1955.

▸ **Axelson Mfg. Corp.** Div. of U. S. Industries. Lee Manning was appointed a field representative, headquartered in Glendive, Montana.

C. C. Call and B. L. Morris were given new assignments within the hydraulic sales and service department. C. C. Call, hydraulic sales engineer will transfer from Wichita Falls, Texas, to Odessa, Texas, and B. L. Morris of the Axelson hydraulic staff from Odessa, Texas, to Casper, Wyoming.

▸ **Wolverine Tube.** Division of Calumet & Hecla, Inc. John E. O'Connor was appointed technical sales representative in the New York district. He will cover New York state, a section of New York City and a part of northern New Jersey.

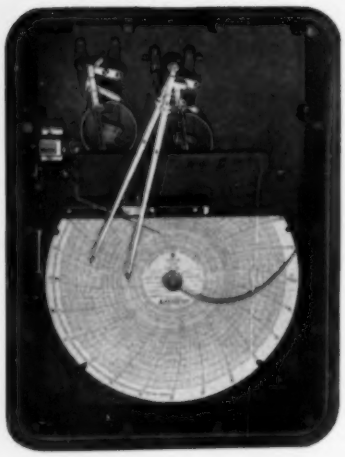
John B. Harbaugh was appointed as technical sales representative in the New York district. We was formerly associated with M. W. Kellogg Co. as process engineer.

J. E. O'Connor

R. E. Barnett

▸ **Jas. P. Marsh Corporation.** Robert E. Barnett was elected vice president for sales. He was formerly sales manager.

Joseph T. Carpenter Jr. joined the company as a sales representative in their Cleveland office.



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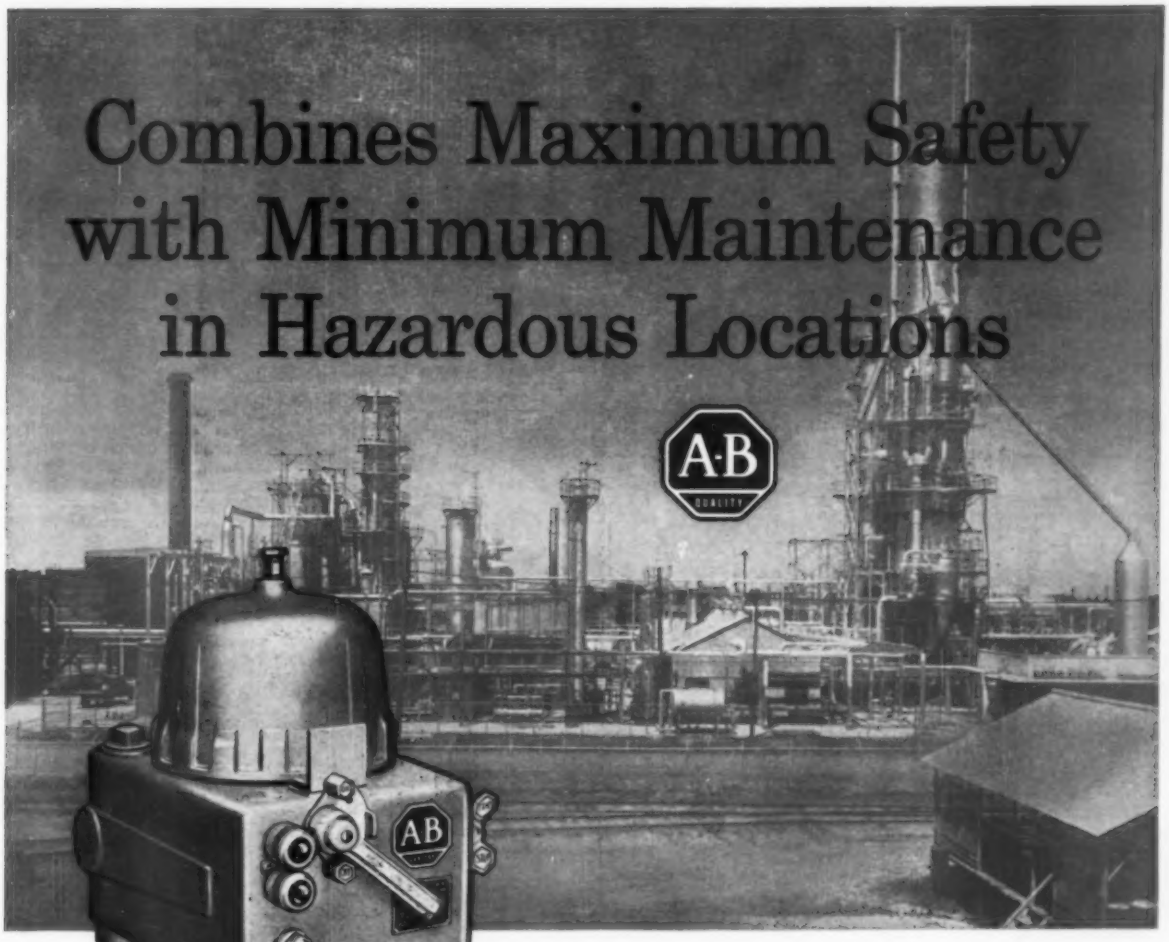

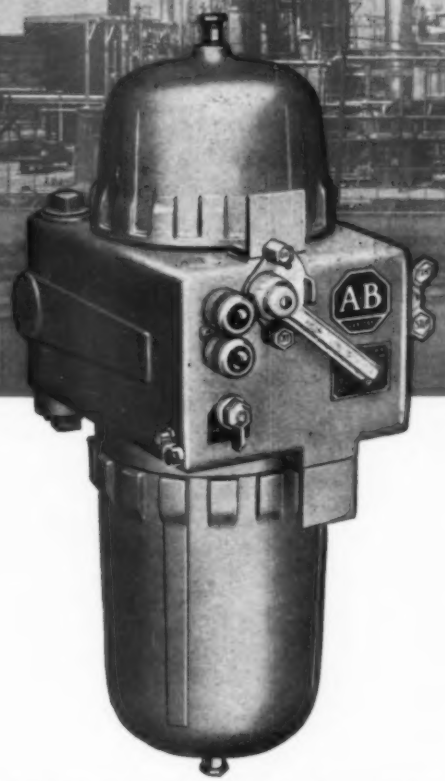

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When safety regulations require special enclosures for your motor control, inspection and maintenance costs can become an important consideration. With Allen-Bradley starters you can practically eliminate these expenses because these starters operate over long periods of time—without attention.

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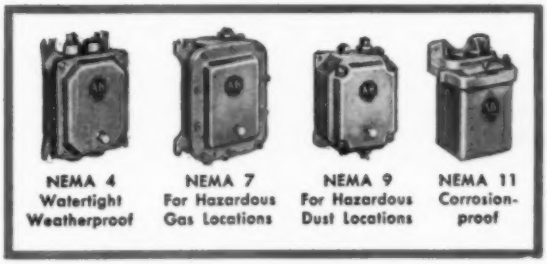

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MOTOR CONTROL
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Hycalog, Inc. J. C. Rush, formerly assistant district manager of the Lafayette, Louisiana, district has been promoted to district manager of the Shreveport district for diamond bit sales. J. E. Woods, formerly assistant division manager, Shreveport, has been transferred to Calgary, Alberta, Canada, where he will be manager of Hycalog, Ltd. a Canadian diamond bit and core barrel subsidiary. J. A. Acker, formerly assistant district manager of Hycalog's well logging office in Casper, Wyoming, has been promoted to manager.

H. G. Allen, formerly district manager for diamond bit sales at Midland, Texas, has been transferred to the same position at Corpus Christi, Texas. H. K. Ware, formerly district manager at Shreveport, for diamond bit sales has been transferred to Casper, Wyoming, where he will be district manager. J. M. Tooke switches from Casper, where he was district manager for well logging to Jackson, Mississippi, as district manager.

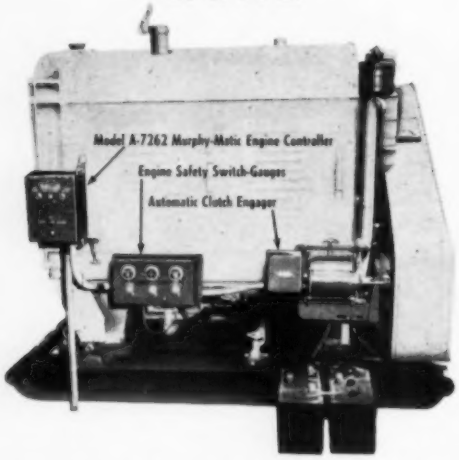
Caterpillar Tractor Company. Jack A. Hasten, district representative in the central sales division was named supervisor of the track-type tractor section of sales development at Peoria. He served 2 years as district representative in the sales territories of Burford - Toothaker Tractor Co., and Thompson Tractor Co., Inc.

J. A. Hasten

MURPHY

See

Safety and Automation Switch-Gauges at I. P. E.



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Baker Filtration Co. of Los Angeles, California, has appointed Jay P. Gould general manager of the Oil Tool Division. William O. Baker is president. The company specializes in engineering and manufacturing of filtration equipment for water injection operations. Both executives have engineering backgrounds. Baker formed Swimquip, Inc. in 1952, and 2 years later was one of the industry's largest makers of filtration equipment. Gould, well known in the oil industry, was formerly division manager for Cosasco Div. of Perfect Circle Co. He originally founded the Carona Oil Specialties and Service Co. in 1950 which became the Cosasco Div. of Perfect Circle Co. in 1956. A former chief engineer and assistant general manager of Iraq Petroleum, he was also with Baash Ross.

J. B. Gould

W. O. Baker

General Electric, Communication Products Department. Kent J. Worthen was appointed to the newly-created position of manager of product planning for point-to-point communication. Previously, he was product planning manager for G-E microwave equipment.

Byron Jackson Division Borg-Warner Corporation. James T. Workman was named administrative assistant. Prior to this assignment he was general superintendent of BJ pump and oilfield products.

J. T. Workman

B. C. Robinson

W. C. Norris, Manufacturer, div. of Dover Corporation. A branch warehouse at Edmonton, Alberta, Canada has been opened under the supervision of Canadian division manager, Bill C. Robinson. Warehouse manager will be Otto R. Perryman.

BJ Service, Inc. Herb Alexander, has been transferred to BJ headquarters at Long Beach as executive assistant. Alexander's spot in Tulsa as Mid-Continent division sales supervisor, is being filled by J. C. Jackson, previously district superintendent at Guymon, Oklahoma. Floyd Long goes from Wichita, Kansas to Guymon as district superintendent; Jack French from Pampa, Texas, to Borger, Texas, as district superintendent; Bob Tull from Guymon to Pampa as sales representative; Charlie Mohr from Breckenridge, Texas, to Houston as division engineer.

Ben F. Kelley Co., Inc., Ray R. Sloan, long-time oil industry equipment salesman, has joined the company as sales engineer. From 1939 until his retirement in 1958, he was a field representative for the engine division of Caterpillar Tractor Company.

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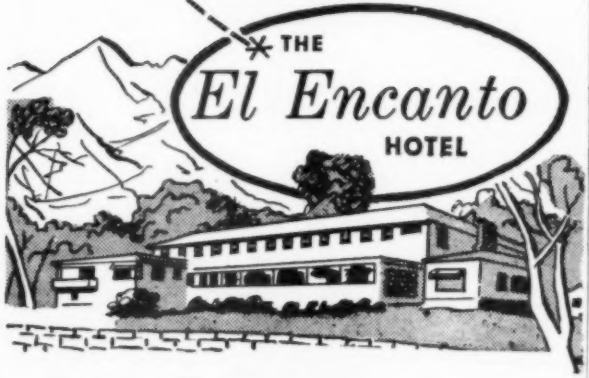

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Trade Parade

Fisher Governor Company. Henry J. Ruston has become associated with Fisher Governor having had several years' experience in process instrumentation, working in the process plants located in Sarnia, Canada.

Colonel Bruce Price, recently retired from the Air Force, is with Fisher and will devote his attention to the position in the export market throughout the world, and to sales engineering of special application projects.

Servicios Tecnicos Atlas, C. A. George M. Yoder, vice president and general manager of Servicios Tecnicos Atlas was a recent visitor to this country from Maracaibo, Venezuela. His company is a subsidiary of Perforating Guns Atlas Corporation, and operates throughout Venezuela and Bolivia.

Accompanying Yoder to the U. S. was

G. M. Yoder

M. J. Muesse

M. J. Muesse, from Caracas, manager of the company's Eastern Venezuela district operations. Both executives attended PGAC's recent Annual Management Conference, at Houston, following which they visited various oil fields to observe some of PGAC's equipment and techniques in operation.

Byron Jackson Tools, Inc. J. T. Carle has been appointed manager of the oil well pump section. Headquarters for the new pump section will be established at the Tulsa (Oklahoma) plant. Carle assumes management responsibilities of 2 basic pump products: the Hydralift hydraulic pump, and a new Submersible pump.

J. T. Carle

Consolidated Electrodynamics Corporation. Formation of six departments to carry out the engineering function of Consolidated Systems Corp., newly formed wholly owned subsidiary was announced. The are C. Kenneth Hines, manager, and Frank C. Bumb, chief engineer, Data Process Systems; Bliss M. Bushman, manager, and Alan D. Marston, chief engineer, Data Processing Systems; John D. Gum, manager, and William D. Schultz, chief engineer, Instrumentations Systems.

Also, James T. Sharpsteen, manager, and Wayne J. Whistler, chief engineer, Electro-mechanical Systems; John C. Alrich, manager, Industrial Systems; and Frank E. Chase, manager, Field Engineering.

Perforating Guns Atlas Corporation. George Decker was promoted from district manager at Lafayette, to district manager of Southern Louisiana district at New Orleans; Jim B. Palmer, from supervisor of nuclear logging at Odessa, Texas, to division operations assistant, covering PGAC's West Texas and New Mexico districts; James F. Blair, from electrical logging engineer at Longview, Texas, to district manager of Mississippi at Laurel; M. G. Burnam, from sales at Abilene, Texas, to station manager at Hobbs, New Mexico; Robert D. Tibbs, from sales at Houston, to district manager of Oklahoma, at Oklahoma City; Earl T. Burger, from sales at Farmington, New Mexico, to district manager of Four Corners district; Donald N. Kahn, from electrical logging supervisor to assistant superintendent of operations, at Houston; Billy D. McInturff, from Houston operations to sales at Woodward, Oklahoma; Tom P. Woods, from Kansas district operations to sales at Great Bend, Kansas.

A new station at Gainesville, Texas, has E. L. Bramhall as sub-station manager and Jack Hall, sales; both came from the station at Bridgeport, Texas.

Celanese Corporation of America. Dr. Joseph J. Cahill was appointed product development engineer in the chemical division. He came to Celanese from the research and development laboratories of the Colgate-Palmolive Company.

W. R Grace & Co. Davidson Chemical Division. John L. Dowell is named controller, chemicals division; A. H. Hanssen Jr., controller, mixed fertilizer division and Edgar L. Linthicum Jr., controller, agricultural chemicals division.

Lane-Wells Company. Rodney S. Durkee, more than 40 years a leader in petroleum and financial circles, has retired. Most recently chairman of the board of directors and chairman of the advisory

committee of Lane-Wells, a division of Dresser Industries, Inc., Durkee was president of Lane-Wells from 1939 to 1954. He is shown here discussing his retirement plans with John J. Neale, president.

The Ohio Injector Company and Jones & Laughlin Supply Division have announced a distribution agreement for OIC valves throughout the U. S. From left to right are W. L. Wolfe, vice president sales, J&L, Rainey Elliott, president, J&L, Roger E. Bremer, executive vice president OIC and G. R. Winder, vice president marketing, OIC, discussing the plans.

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Core Laboratories, Inc., has announced plans to construct a 40,000 sq ft home office building on a four-acre site in the Empire Central business development area, adjacent to the new Stemmons Expressway, Dallas, Texas. The $750,000 00 investment is financed by Core Lab's employee pension fund, and climaxes a five-year expansion and modernization program throughout the company's domestic and foreign operations. The new two-story building will house Core Lab's administrative, engineering and consulting, special core analysis, reservoir fluid, data processing, research, accounting, and equipment development and maintenance departments.

Series 2800–The oil man's Level Controller for Lease Automation

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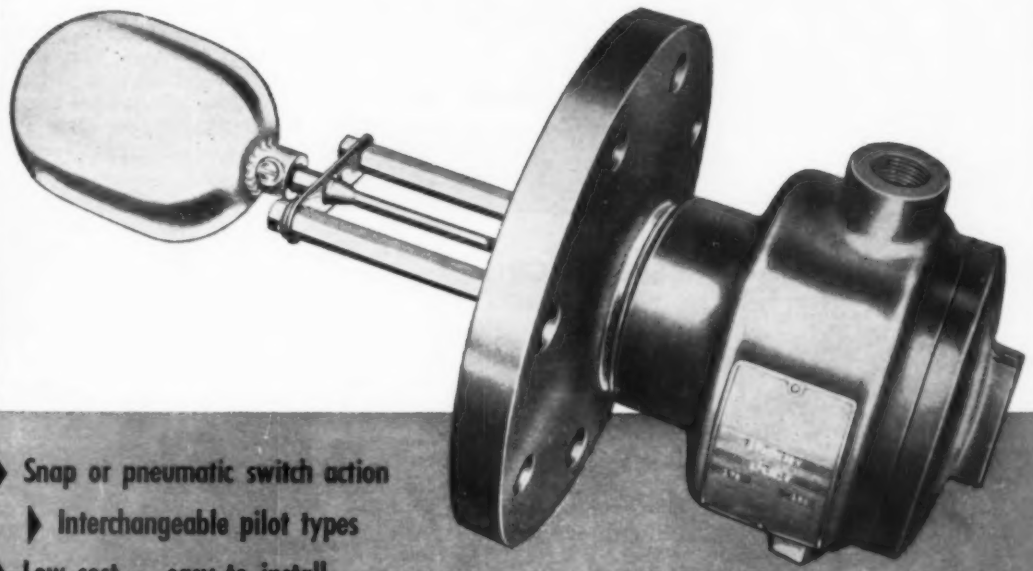

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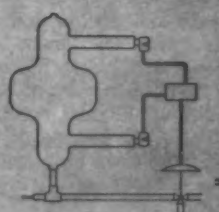

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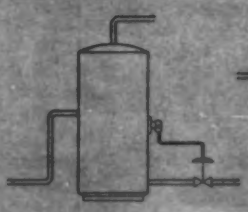

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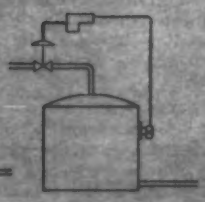

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UNIONS

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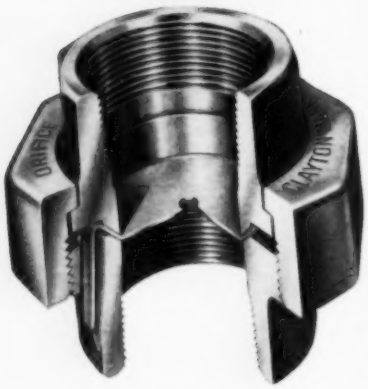
BEVELED ORIFICE



Designed to join sections of pipe and at the same time measure or control the flow of liquids and gases under pressure at high or low temperatures, this new BEVELED ORIFICE Union introduced by Clayton Mark finds application in chemical processing plants, oil production facilities, utility power plants, atomic installations and countless other industries.

The union is equipped with a one-piece, stainless steel disc shaped to fit the contour of the seats (ball to cone), thus eliminating the need for gaskets. It is also easy to install on both horizontal and vertical lines.

At leading Industrial Distributors in all 49 states.

These carbon steel unions are available in all sizes from ¼" to 2" pipe sizes. Special stainless steel orifice unions can be furnished on special request in 304 or 316 types.

Specify the brand – Clayton Mark BEVELED ORIFICE

Write today for additional information.

CLAYTON MARK & Co.

1900 DEMPSTER STREET
EVANSTON, ILLINOIS

Women at Work

Does Chemical Research

Mrs. Maxine Brenneman, one of Esso Research and Engineering Company's authorities on chemical geology of oil, began her professional career in a completely opposite direction.

Her first job was as a social service worker for a West Virginia home for delinquent girls.

In those days, she recalls, there were few opportunities for a gal with a degree in chemistry.

As a social worker, Maxine traveled from town to town throughout West Virginia. Her interest in chemistry never flagged, however, and when the chance came to study for her master's under a fellowship, back she went to the University of West Virginia.

With an MS after her name, she decided that next to being a working chemist, teaching the subject might be

best after all. She accepted a teacher's post at a high school on the West Virginia-Kentucky border.

In time she married Albert E. Brenneman, a chemical engineer. When her husband later took a job with Esso Research in Linden, New Jersey, Maxine settled down as a housewife, content to satisfy the chemist's side of her with occasional substitute teaching stints.

Then World War II changed things. The company began hiring qualified women for technical jobs. Maxine was one of them.

Today she heads the Organic Geochemicals Group of the firm's Chemicals Research Division, and has won recognition for her studies of how oil is formed.

One of her more interesting assignments a few years ago was to analyze samples of black, oily-looking water discovered in a remote region of southern Venezuela. Maxine put the samples through test after test, and reported ruefully the water's dark color had nothing to do with oil. It was caused by a vegetable matter.

She occasionally gets away from the lab to pursue her work in the oil fields or to present a paper at a meeting of a technical association.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Books to Read

Transactions of Short Course and Conference on Automation and Computers, *published by College of Engineering, University of Texas, Austin. Pages, 324. Price, $15.*

This two-volume record of the June 2-4, 1958 Short Course and Conference on Automation and Computers at Austin contains 24 papers on various aspects of automation and automation equipment. The course was sponsored by the University's College of Engineering and the Society of Petroleum Engineers. Subject matter contained in the Transactions, authored by automation leaders directing the course, range from general and technical aspects of digital and analog computers, use of computers in industrial research, well logging problems, computer programming, financial justification for automation, electro-acoustical analog for pulsation suppression and control in gas compression stations, and many others.

Selected Electron Micrographs of Clays and Other Fine-Grained Minerals, *by Thomas F. Bates. Published by the College of Mineral Industries of Pennsylvania State University, University Park, Pennsylvania. Pages, 61. Price, $2.*

Ever look at Wyoming bentonite—or even chert—through the eyes of an electron microscope? Beautiful, to say the least. This attractive final report on the investigation of morphology, origin and structure, of fine-grained minerals (Project E-27), contains a representative group of electron micrographs of mineral materials such as clays, serpentines, associated silicates and certain vanadates and may serve as a micrograph reference of the clay minerals.

Engineers' Job Directory (5th edition). *Published by Decision /Inc., 4601 Red Bank Road, Cincinnati 27, Ohio. Pages, 72. Price, $5.*

Decision/Inc., management consulting firm in the technical manpower field, has published the fifth (1959) edition of Engineers' Job Directory. Subtitled the Placement Guide for Executives, Engineers and Scientists. EJD contains information on 1000 companies. Basis for selection were such factors as each conpany's plans for expansion, personnel requirements, new products, employee relations and financial standings. Information on each firm contains such facts as company name, address, phone number, type of industry, products, number of employees and whom to contact. One chapter tells how to write your resume to apply for a job.

CONTROL PARAFFIN

with BrakeSol

at

LOW, LOW COST!

NOW is the time to set up a "control program" with the constant injection of economical BrakeSol. . . . the chemical that holds paraffin in suspension from formation to refinery. BrakeSol is the most effective chemical for treating all types of paraffin conditions. It is approved by refiners . . . contains no chlorinated solvents or other organic halides or sulphides. Contact your nearby BrakeSol Treating Engineer or Supply Store for information on how your paraffin problems can be eliminated economically See our Exhibit at the IPE.

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P. O. BOX 9506 • OKLAHOMA CITY, OKLA.
EXPORT DISTRIBUTOR: THE NATIONAL SUPPLY CO., EXPORT DIVISION

When the Southern California Gas Company planned the Ducommun St., Compressor Station, they anticipated a bad neighborhood relation situation, not to mention an intolerable internal noise condition, unless something was done about quieting the engine compressors.

Logically the problem was turned over to the Burgess-Manning Company . . . specialists in noise elimination. After a scientific analysis of the situation they recommended, designed and built especially engineered Burgess-Manning Air Intake Cleaner Silencers and Burgess-Manning Exhaust Snubbers for each of the eight Ingersoll-Rand Gas Compressors.

In addition, special Burgess-Manning Pulsation Snubbers were installed in the second stage discharge of the compressors to eliminate gas pulsation in the line. As a result, the Ducommun St. Plant is one of the quietest of its type anywhere, an asset to its community and a pleasure to work in. The elimination of pulsation will keep maintenance costs at a minimum.

Successful installations of this kind are possible because of the years of research, study and experiment in the cause and effect of noise that preceded them. Burgess-Manning Engineers are specialists in the elimination of exhaust and intake noise and the pipe line vibration that pyramids maintenance costs.

When such a problem arises in your plant or projected installations, consult Burgess-Manning for a successful, economical solution. They can engineer excessive noise and vibration right out of your equipment and make a "Good Neighbor" out of your plant too!

Eliminate Intake and Exhaust Noise, and Piping Pulsation Problems... Consult Burgess-Manning Engineers

Sound Engineering

BURGESS-MANNING COMPANY

Industrial Silencer Division

9241 Sovereign Row, Dallas 35, Texas

Libertyville, Illinois

Onan introduces Instapac

. . . instantaneous standby power for microwave systems

- NO INTERRUPTIONS OF ANY KIND OF SIGNAL
- NO INTERFERENCE WITH POWER LINE FREQUENCY
- NO MOVING PARTS; NO IDLING PHASE
- CAN BE FITTED TO EXISTING STANDBY INSTALLATIONS

Heart of the Onan Instapac is a transistorized inverter operating from battery power. When commercial power supply is interrupted, an instantaneous transfer relay switches radio equipment from the power line to the inverter while the Onan Standby Generator set comes up to voltage. The load then switches to the generator set.

When normal power is restored, the Instapac supplies power for the interval when power is switched from generator to normal source.

Relay switching time ranges from .008 to .033 seconds. This brief interruption is eliminated by the filter network in the radio power supply.

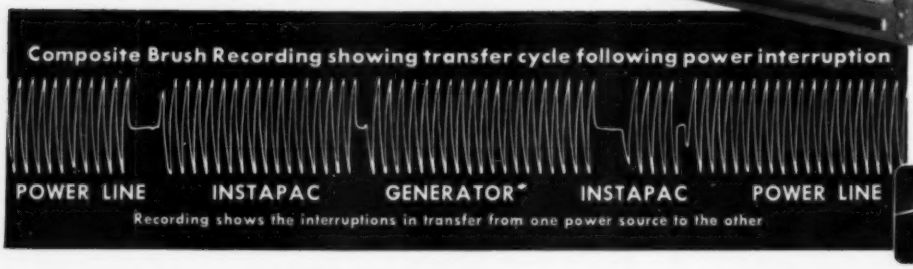
Complete packaged units

The Onan Instapac includes, in addition to the inverter, a load transfer relay, 36-volt battery charger, meters and terminals, mounted in a steel cabinet. Batteries are externally located.

The Instapac system provides instantaneous standby power without the disadvantages inherent in other systems. Since normal power supply is not connected through the inverter, the Instapac does not add components to the line which might break down or interfere with power line frequency.

The Instapac will convert existing standby installations to instantaneous systems. Models up to 5KVA.

SEE THE INSTAPAC AT THE OIL EXPOSITION


Composite Brush Recording showing transfer cycle following power interruption
POWER LINE
INSTAPAC
GENERATOR
INSTAPAC
POWER LINE
Recording shows the interruptions in transfer from one power source to the other

Write or call (FEderal 2-1155, Mpls.) for specifications

Onan PRODUCTS

D. W. ONAN & SONS INC.

ELECTRIC PLANTS GENERATORS ENGINES ENGINE-COMPRESSORS

3283 University Avenue S. E. • Minneapolis 14, Minnesota

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Laugh with Barney

The fellow had wooed and won the love of his life, and decided it was time to take her home to meet his family. "This is my intended wife," he announced to his parents.

His father took him aside when the opportunity presented itself. "This girl doesn't look like much to me," he said.

"But, father," the boy said, "this girl is a baroness. Doesn't that impress you?"

"You mean," exclaimed the father, "that she can't have any children?"

* * *

Barney knows a prospective groom who had so much fun at his bachelor party that he postponed the wedding.

* * *

A Britisher and an American were on a ship returning to America, and the American was berating the Britisher and his way of life. "The trouble with you English," he ranted, "is that you stick together too much. There should be more intermingling. In my blood there's Russian, Spanish, Greek, and Italian." The Britisher looked up and said, "That was very sporting of your mother."

* * *

"Did you read in the paper about the fellow who beat his wife to death with a golf club?"

"No, not really? How many strokes did he take?"

* * *

Horace McVane entered the psychiatrist's office in a highly emotional state. "Doc," he groaned, "you've got to do something for me."

"There, there," the analyst soothed him, "surely it can't be that bad. Now just lie down, relax and start from the beginning."

"Every night," began McVane, "I have the same dream, I dream a gorgeous blonde chases me all through the house. And then, when she finally catches me and tries to make love to me, I push her away. Always I keep pushing her away."

"I see," mused the doctor, "And just what do you expect me to do?"

"Doc," he pleaded, "break my arms!"

* * *

A bunch of elderly married men were boasting about their families.

"I've got five sons," said one, "enough for a basketball team."

"I've got six boys myself," another bragged, "could make a hockey team."

"Got nine, all boys," said a third, "a baseball team."

They all turned to a little fellow who had been standing quietly in a corner. "How many children you got?" asked one of the fathers.

"Eighteen daughters," was the weary reply. "A golf course."

* * *

First Man: I hear you just had an accident.

Second Man: Yes, it was pretty bad, but I collected $20,000, and my wife who was in the accident with me got $5,000.

First Man: Did she get hurt?

Second Man: No, but I had the presence of mind to kick her in the face during the confusion.

* * *

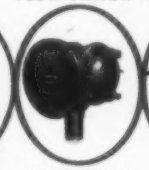
Seen in the paper: Man wants apartment large enough to lay his hat, coat and a few friends.

WANTED: TOUGH JOBS!*

***FOR A METER BODY BUILT TO 'TAKE IT'!**

The Model 199 Differential Pressure Unit, a BARTON development, was designed to answer industry's needs for a compact, yet rugged device for accurately sensing differential pressure. It has found extensive use in the many fields of Instrumentation and Automation for the precise measurement of FLOW, Liquid Level and Differential Pressure. The unit incorporates the patented BARTON RUPTURE-PROOF BELLOWS principle, internal motion pickup and torque tube transmission to the exterior of the housing. The Model 199 Differential Pressure Units are available with differential pressure ranges from 0-20" W.C. to 0-50 PSI with safe working pressures to 6,000 PSIG. All BARTON bellows units are hydraulically tested and overranged to 1.5 times the safe working pressure, regardless of the differential range.

For further information, contact Barton Sales Representatives in principal cities.

model 200 INDICATOR	model 202 RECORDER	model 211 FLOW SWITCH	model 214 TRANSMITTER	model 236 INTEGRATOR	model 237 CONTROLLER
					
Bull. 11C4	Bull. 11C4	Bull. 211-1	Bull. 214-1	Bull. 236-1	Bull. 237-1

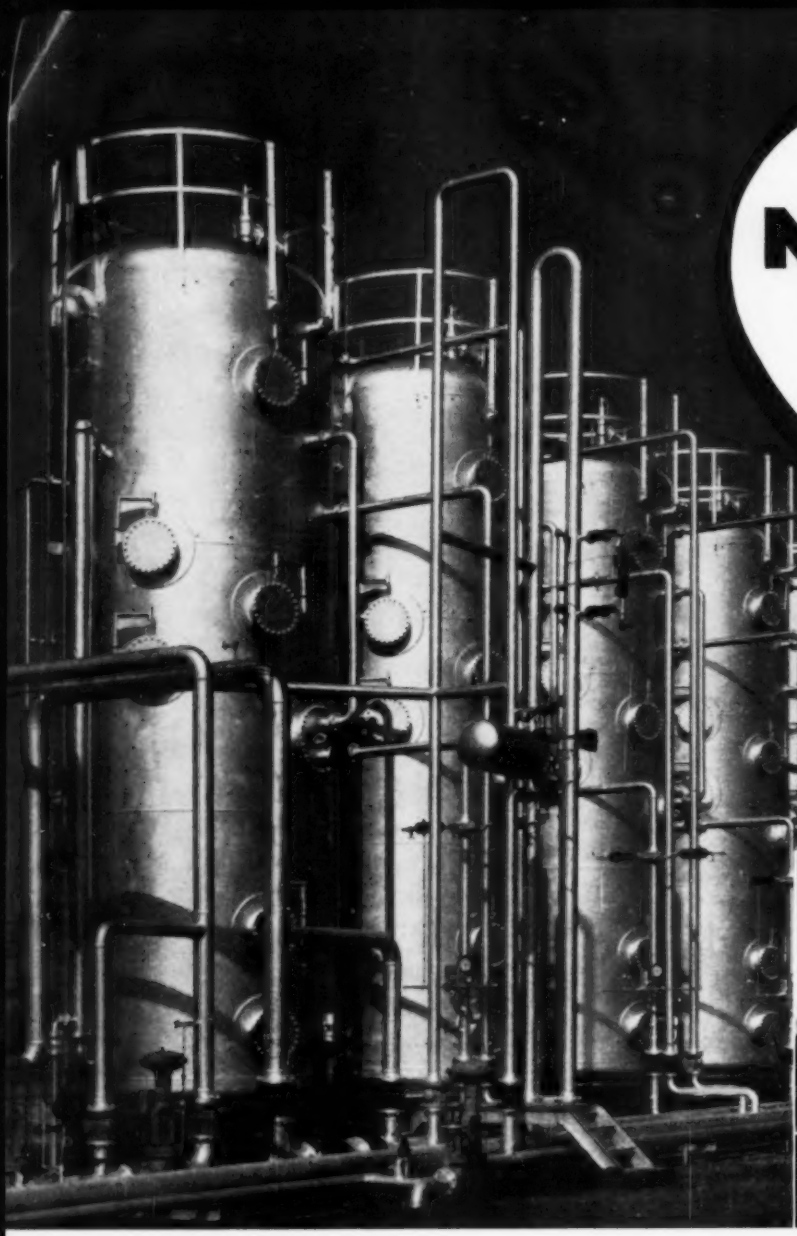
199-357

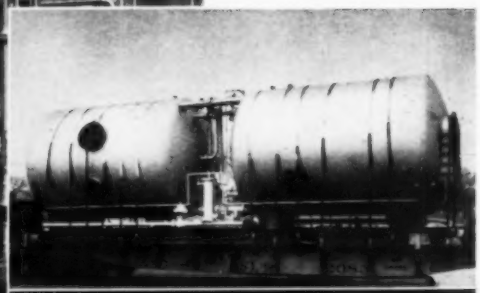
BARTON INSTRUMENT CORPORATION

580 MONTEREY PASS ROAD, MONTEREY PARK, CALIFORNIA

NATIONAL®

XCP TREATERS
25,000 BPD
at 100 PSI





Another High Capacity yet Portable Vertical Flow Treater in horizontal shell . . . This new "VHF" type enroute to an overseas location.

Treating tough emulsions, especially in wholesale lots, requires the best in specialized equipment backed by long-standing design experience and techniques. National meets both requirements thanks to 33 years of DOING IT . . . plus unique shop facilities adequate to meet any physical requirement.

Whether a matter of treating 25,000 BPD at 100 psi as shown above, or a need to handle jobs from 2000 BPD to 9000 BPD of foamy, asphaltic Venezuelan crude through a SINGLE vessel, National is DOING IT. National Treaters are in service throughout the free world.

It's a National®

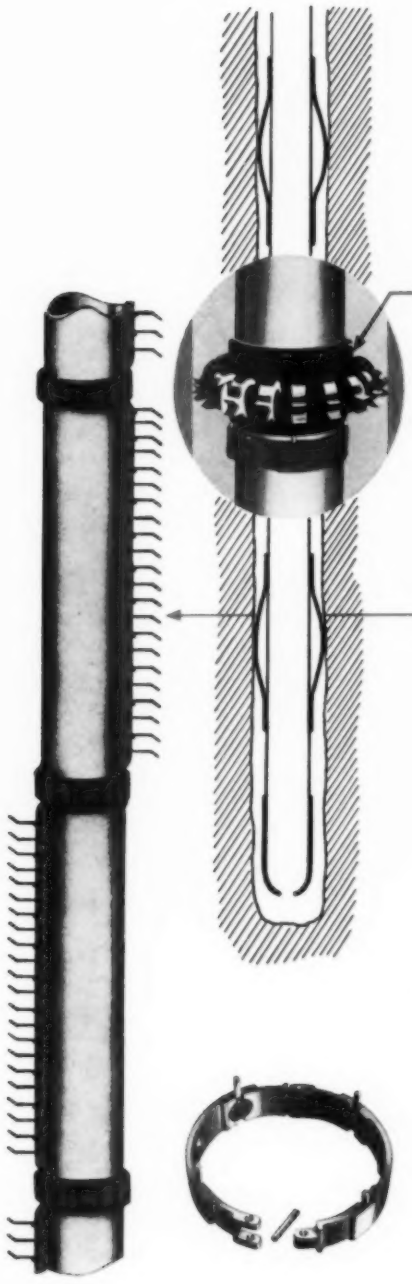
NATIONAL TANK COMPANY

DRAWER 1710

TULSA, OKLAHOMA

IT'S NO SECRET!

BETTER BONDING BEGINS WITH BETTER WALL CLEANERS by HALLIBURTON



Roto Wall Cleaners Installed with Vise-Lok Limit Clamp

The secret of successfully stronger primary cementing jobs is a better bond ... to minimize precautionary and remedial squeeze jobs.

Halliburton Roto Wall Cleaners and Recipo Wall Cleaners ... are field-proven and are first-choice abrading devices by thousands of well operators for efficient performance—under the most punishing downhole conditions—for the removal of undesirable filter and mud cake from the bore hole ... allowing a stronger bonding of cement to formation and casing in primary cementing.

RECIPO WALL CLEANER ... reciprocating type cleaner

New design offers these advantages:

- Removal of tough filter cake—without damage to hole wall.
- Circulating pressures and bridging action of cuttings reduced.
- Flexible rubber cleaning fingers minimize bore hole or filter cake damage while running in.
- Tough wide cleaning fingers cover more bore hole area and clean more thoroughly.
- Wide cleaning fingers help to break channeling action of cement.
- Cleaning effectiveness is increased—yet "finger" damage is decreased due to their flexibility which prevents permanent bending.
- Hinged for fast and easy latch-on installation.

ROTO WALL CLEANERS ... rotary type cleaner

New standard designed recessed base and "Claw-Type" Cleaning Spikes provide:

- Installation on casing by Vise-Lok Limit Clamp or tack welding.
- No bridging off of annulus.
- Permits free-flow of fluids while running casing, cementing and circulating.
- Minimum disturbance of mud cake while running casing to bottom reduces lost circulation problems.
- Reduces hazard of "sticking casing" off casing point.
- Turbulent action of cleaning spikes gives better cement uniformity.
- Construction allows minimum damage to spikes or filter cake while running in—provides maximum force for cleaning when rotating casing.
- Economy—one size base fits all O.D. sizes of casing.
- Slim Hole Roto Wall Cleaners are available for better cementing where annulus between casing and bore hole is small.

VISE-LOK LIMIT CLAMPS ... equal to welding even under severe torque loads!

A new method for positioning auxiliary equipment on casing without welding ... each clamp has these outstanding features:

- 20,000 pound load-carrying capacity—greater than any non-weld limit clamp or stop collar tested.
- Design and superior lock-on power of the special disc-type slips grip the casing and prevents movement of auxiliary casing equipment.
- Provides selective location and limits travel in either direction.
- Easy installation with hinged design.

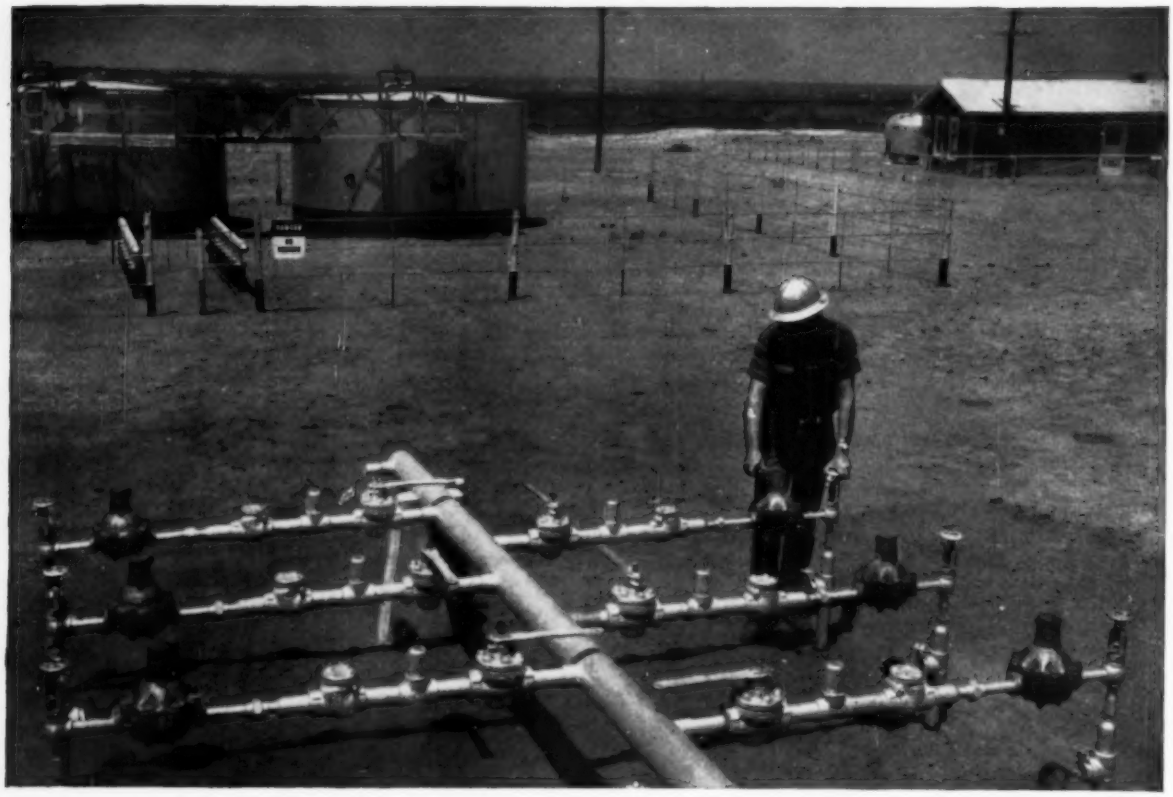
For a better bond and cement uniformity on your primary cementing job ... check with your Halliburton Representative about the unique features of Recipo Wall Cleaners ... Roto Wall Cleaners and the *new* method of installation with the Vise-Lok Limit Clamp.

HALLIBURTON

CEMENTING SERVICES

HALLIBURTON OIL WELL CEMENTING COMPANY • DUNCAN, OKLAHOMA

"284 SERVICE CENTERS — JUST MINUTES AWAY FROM YOUR WELL!"



Write Precision and Dependability into Secondary Recovery

WATER FLOOD *with* ROCKWELL

FIVE POINTER METERS

THE ORIGINAL AND BEST
HIGH PRESSURE METER
FOR WATER FLOOD SERVICE

Rockwell developed the first successful high pressure meter to measure water forced into the ground under pressure at spaced flooding points. Successive improvements in design and construction make today's Rockwell "five-pointers" an even better buy. They handle this tough service with long lasting precision accuracy. And they are strongly designed to operate safely under the extremely high pressures encountered, and to withstand exposure to unfavorable atmospheric conditions. The thousands in daily use testify to the soundness of this "purpose-built" construction. Stocked by leading supply stores. For literature, write Rockwell Manufacturing Company, Pittsburgh 8, Pa.

BUY AT YOUR SUPPLY STORE

WATER FLOOD METERS
another fine product by
ROCKWELL

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Of Things To Come . . . In Oil

POLAR DRILLING? The day is not too far away. Applications have been placed for rights to drill on leases in the Canadian-owned islands above the Arctic Circle. Major U.S. and Canadian companies have asked for more than 70,000,000 acres in perennially ice-covered areas. Inherent drilling problems might be solved by using small atomic reactors to provide both heat and power at the well site, one report suggests.

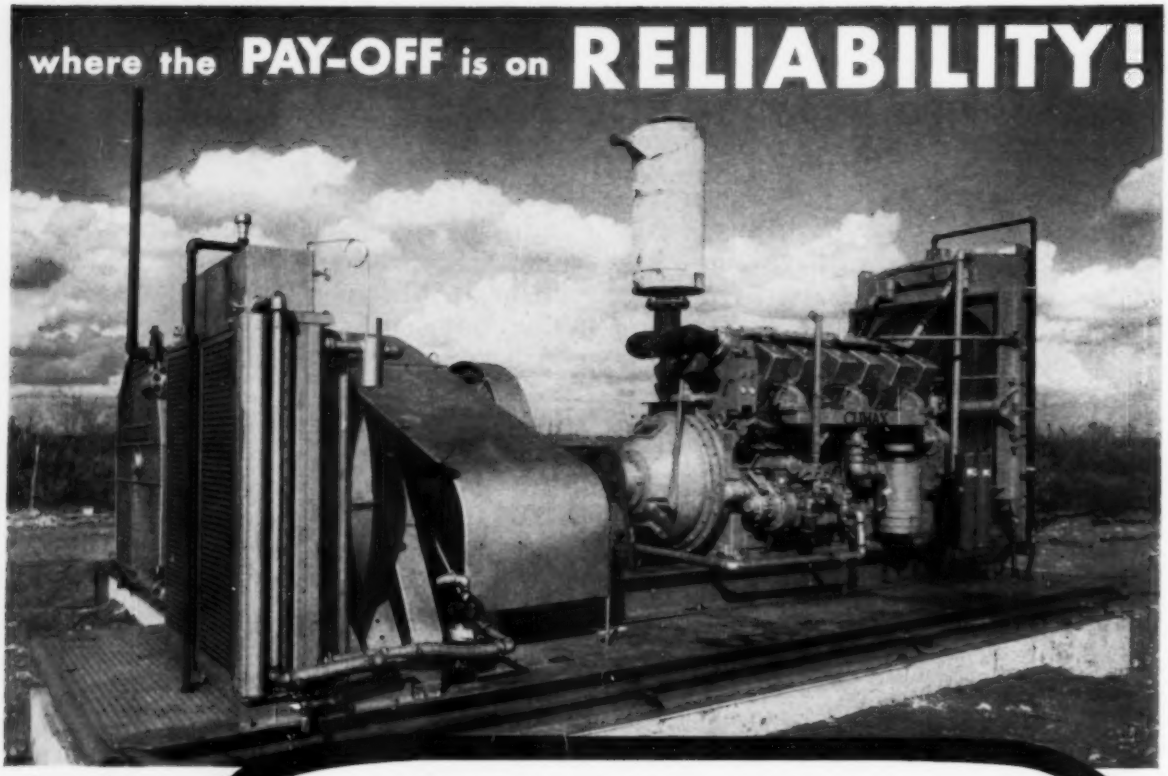
TWO NUCLEAR EXPLOSIONS TO PRODUCE OIL are tentatively scheduled. One, and probably the first to be detonated, will be in Canada's Athabasca tar sands. A similar thermonuclear blast is being planned by U.S. government in the Green River oil shale area in the Rocky Mountains — but is having trouble enlisting active (financial) participation in its $4 to $6-million project. Athabasca test is set up for next winter, but still lacking Canadian Cabinet permission — which is likely.

NEW STEELS, just out of the research laboratory, may provide "breakthroughs" necessary to drill deeper and deeper wells without tubular goods difficulty. One steel now being tested has shown tensile strengths of more than 400,000 psi — level never before reached with any metal, reports Dr. Clarence H. Lorig, ASM president and technical director of Battelle Memorial Institute. This new metal, if similar strengths can be matched in production quantities, can compete with titanium alloys on strength-to-weight basis, and is reported to have high ductility as compared to similar compositions of steel which are notoriously brittle. In other research, Lorig states that metal experts are working on new steels effective up to 4000 and 5000 F — which may be necessary to penetrate deeper into the cooling crust.

LEASE AUTOMATIC CUSTODY TRANSFER SYSTEMS in field operation may double in a year, at current rate of completion and conservation commission acceptance. More than 100 LACT units are now in use in 14 oil producing states. Among newest is Shell's installation in Good Hope field, St. Charles Parish, Louisiana. Crude is measured, metered (imprinting meter reading directly on run ticket) and is continuously sampled. Shell now operates 56 LACT units in the U.S.

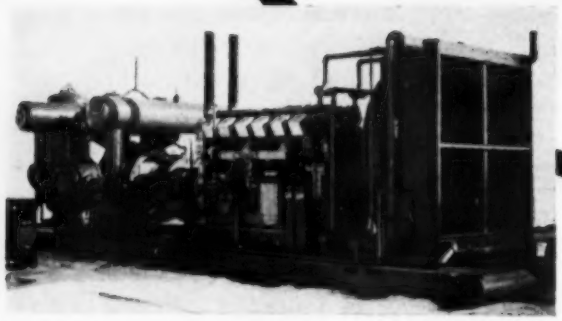
MISSISSIPPI TO PROVE MORE ATTRACTIVE for oil exploration in coming years, says Howard C. Pyle, president of Monterey Oil Company. Monterey has just opened district office in Jackson, Mississippi, to facilitate active exploration in that state in "50 selected areas." Pyle says resurgence of Mississippi as one of the nation's more attractive regions for exploration is indicated by high ratio of discovery in Lower Cretaceous formations during recent years, with "exploration successes at a ratio of about 1 to 5 since the first discovery," with many new fields giving promise of attaining major importance.

where the PAY-OFF is on RELIABILITY!



Climax and Gardner-Denver combination—central Texas.

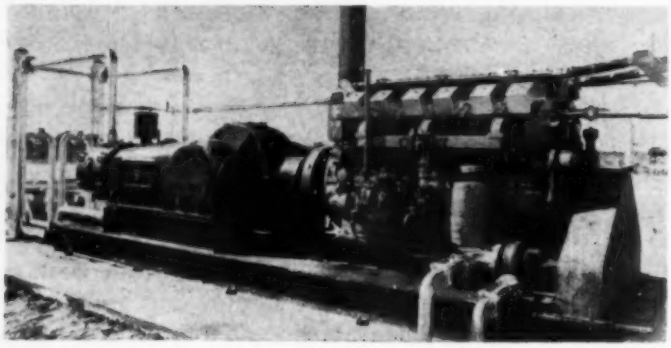
CLIMAX COMPRESSOR POWER



In all the oil fields...

Climax V-125 driving a Joy compressor in Colorado.

300 hp Climax and Oil Well Supply compressor in southern Texas.



Climax Engines have proven their reliability in hundreds of compressor installations. Single, well-balanced design, rugged construction, and quality materials make them smooth running . . . for years!

Send for descriptive literature

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FACTORY—CLINTON, IOWA

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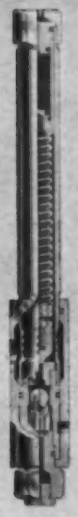
1934 · 1959 · 25 YEARS · SERVING THE OIL INDUSTRY

review of Merla's 25 years of valve progress

1934

TYPE "B" differential valve



TYPE "L" pressure operated

TYPE WF3 pilot operated

1959

TYPE WF8R wire line retrievable valve

Merla research and development leadership through 25 years of oil progress has accomplished its goal: To recognize industry needs . . . then meet requirements of operators with top-notch, trouble-free equipment. This has made Merla the leader in gas lift equipment for a quarter-century.

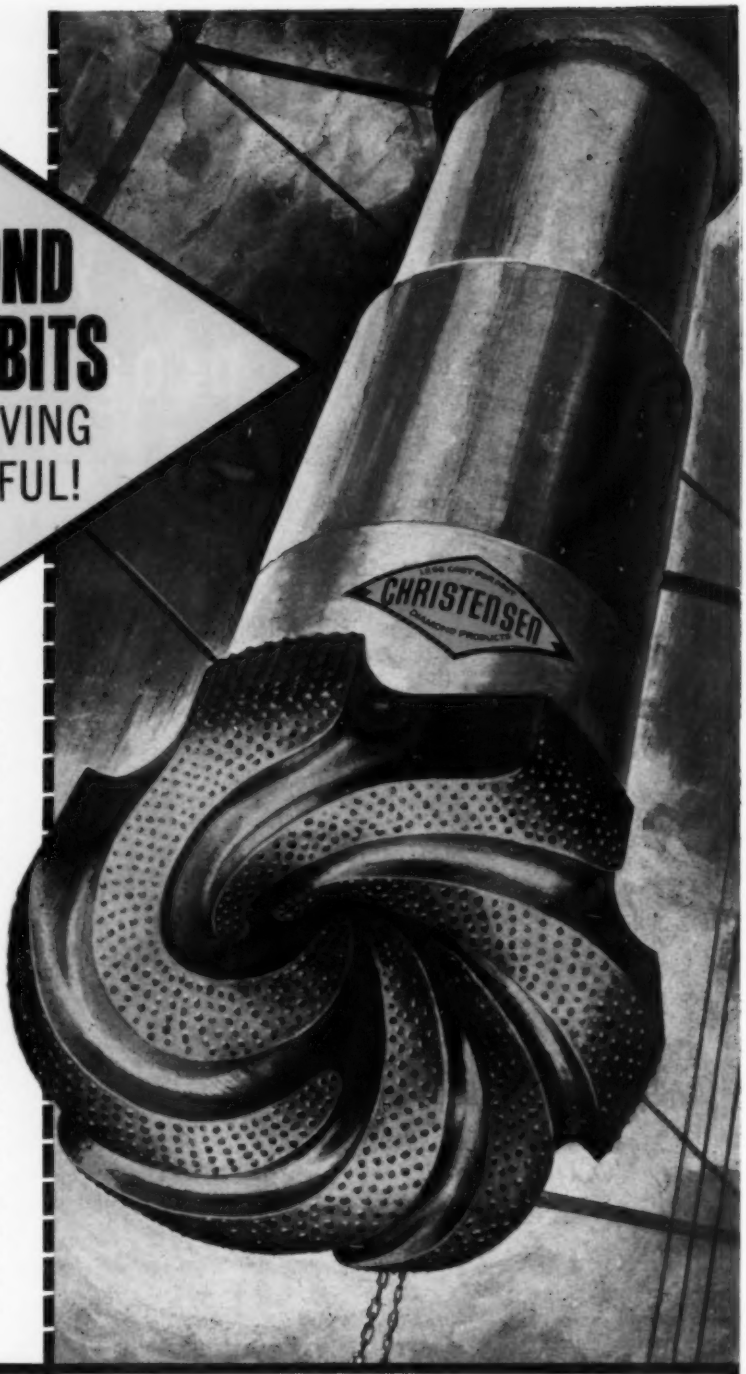
TOOL MERLA CORP

manufacturers of oil tools and gas lift equipment

Contact your nearest Merla representative or
MERLA TOOL CORPORATION • P. O. BOX 2576
DALLAS 21, TEXAS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

DIAMOND TURBO-BITS
NOW PROVING SUCCESSFUL!



The introduction of the turbodrill has provided the oil industry with a tool of great promise. However, the turbo demands a bit that can absorb and effectively utilize its increased downhole power, one that can withstand high rotational speeds and increased fluid volumes. Diamond bits have long been known for their inherent long life and ability to increase penetration rates as rotational speeds increase. Because of these qualities, diamond bits have been tested with the turbodrill in many parts of the United States and Europe. Many thousands of feet have been drilled, and these tests have proven that under a wide variety of drilling conditions, the diamond bit-turbodrill combination can reduce drilling costs.

Christensen has accumulated data on the use of diamond bits with the turbodrill throughout the world, any portion of which is available to operators considering the use of this tool.

For detailed performance information about successful diamond bit-turbodrill applications, write or call Christensen Diamond Products. Ask for brochure number SD-650.

Diamonds Mean, "Less cost per foot."

CHRISTENSEN DIAMOND PRODUCTS

1937 SOUTH SECOND WEST • SALT LAKE CITY, UTAH

ANOTHER
PARKERSBURG
OUTSTANDING
ENGINEERING
ACHIEVEMENT

TOP PERFORMANCE THAT ALL ADDS UP TO PARKERSBURG

CHAIN-DRIVEN OR GEARED PUMPING UNITS

Careful attention to detail, from engineering to the complete product, is your assurance of dependable performance in every **PARKERSBURG** Pumping Unit. From the smallest to the largest heavy-duty units, **PARKERSBURG** Pumpers are famous for economy and longer trouble-free operation.

PARKERSBURG for pumping units of *every* type to meet *every* need.

PARKERSBURG for the most complete line of *wide-base portable units.*

PARKERSBURG for *quality products at competitive prices.*

PARKERSBURG for *experience* and *know-how* . . . over 25 years in the pumping unit field.

PARKERSBURG for a *field service* surpassed by none.

PARKERSBURG for the most *prompt delivery* possible, direct to your lease.

THE PARKERSBURG RIG AND REEL CO. — PARKERSBURG WEST VIRGINIA — MADE IN U.S.A.

See Your
PARKERSBURG
Man Today!

THE
PARKERSBURG
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PESA

Parkersburg Pumping Units are available through the following supply stores: American Pipe & Supply Co., Beacon Supply Co., Bovaird Supply Co., Canadian Equipment Sales & Service Co., Ltd., C. W. Cotton Supply Co., Franklin Supply Co., Houston Oilfield Material Co., Inc., Industrial Supply Co., Iverson Supply Co., Midland Supply Co., Inc., Mountain Iron and Supply Co., Murray-Brooks, Inc., The Producers Supply & Tool Co., Republic Supply Co., Rodman Supply Co., Superior Iron Works & Supply Co., United Supply & Manufacturing Co., Wilson Supply Co.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

The big advantages of Taper-Lock mounting are now available for practically all of your sprocket installations. Below is listed the new wide range of types and sizes offered by Dodge!

This important expansion of the Dodge line is the result of the enormous popularity of the Taper-Lock idea. Taper-Lock Sprockets are *modern*. Industry likes them because they go straight from shelf to shaft without machining—saving time. They are "easy on—easy off"—saving work. Their bushings can be re-used, not only in replacement sprockets, but in sprockets of different sizes and also in Taper-Lock Sheaves, Couplings, Conveyor Pulleys. Taper-Lock saves inventory—and money!

Dodge Taper-Lock Sprockets and Dodge Roller Chain are available through your local Dodge Distributor. Call him. Or write us for bulletin.

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ROLLER CHAIN DRIVES ARE NOW AVAILABLE IN A NEW WIDE RANGE OF TYPES AND SIZES

No Reboring!

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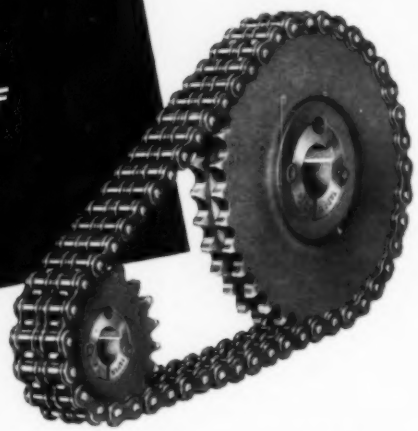

DOUBLE PITCH CHAIN and SPROCKETS

Transmission Series (No. 2040 to 2080) and Conveyor Series (No. 2040 to 2100). Sprockets to 112 teeth—including, for the first time, stock sprockets of 17, 19, 21, 23, 25 and 35 teeth *made especially for double pitch chain*. Introduced by Dodge, these sprockets are designed for even distribution of tooth engagement and absolute accuracy of mesh. Wear is reduced by half. Life of chain and sprocket is doubled!

PLATE SPROCKETS

Steel Plate, Type A. No. 35 to 120. Mandrel bore, bored-to-size or Taper-Lock.

SINGLE STRAND CHAIN and SPROCKETS

No. 35 to 160. Sprockets to 112 teeth.

DOUBLE STRAND CHAIN and SPROCKETS

No. 35-2 to 80-2. Sprockets to 112 teeth.

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of Mishawaka, Ind.

CALL THE TRANSMISSIONEER — your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

DODGE MANUFACTURING CORPORATION, 7900 Union Street, Mishawaka, Indiana

Anti-lock prevents relative rotation between anchor cage and tubing while running

Re-latch threads prevent upper slips from setting until ready.

Long, flexible drag springs allow easy recovery in case of washover.

Special seal protects against fouling from sand or scale.

Internal shoulder creates a differential piston inside rubber to cause a tighter seal.

Full setting force is transmitted to packing element through lower head. No scrubbing action between lower slips and casing wall during setting stroke.

Guiberson permanent completion

TYPE A DRILLABLE PACKER

runs and sets easily, quickly

- ***Built-in safety against premature setting***
- ***Set and produce in ½ tubing trip***
- ***Unequalled rubber seal***

Guiberson Type A Drillable Packer gives you a versatile packer for many uses..single or multiple zone production, acidizing, pressuring operations, water-flooding, testing, corrosion control and many others.

New safety factors against premature setting are provided since the transmitting of drag from tight casing or impact from junk is direct to the tubing string.

The Type A can be set and placed in production with only ½ tubing trip. Spacing problems are easier, especially when run in combination with a multiple zone packer. From rig floor to completion, the Type A runs and sets faster than any other permanent packer.

Guiberson superior quality rubber and special lead-alloy thimbles compress fully for a leak-proof seal. Setting is quick, easy and uncomplicated..may be set by wire line. Available in 5″ through 7⅝″ sizes for 2″ or 2½″ tubing with a full line of stingers and accessories. Ask your Guiberson representative for a recommended installation or write for full details.

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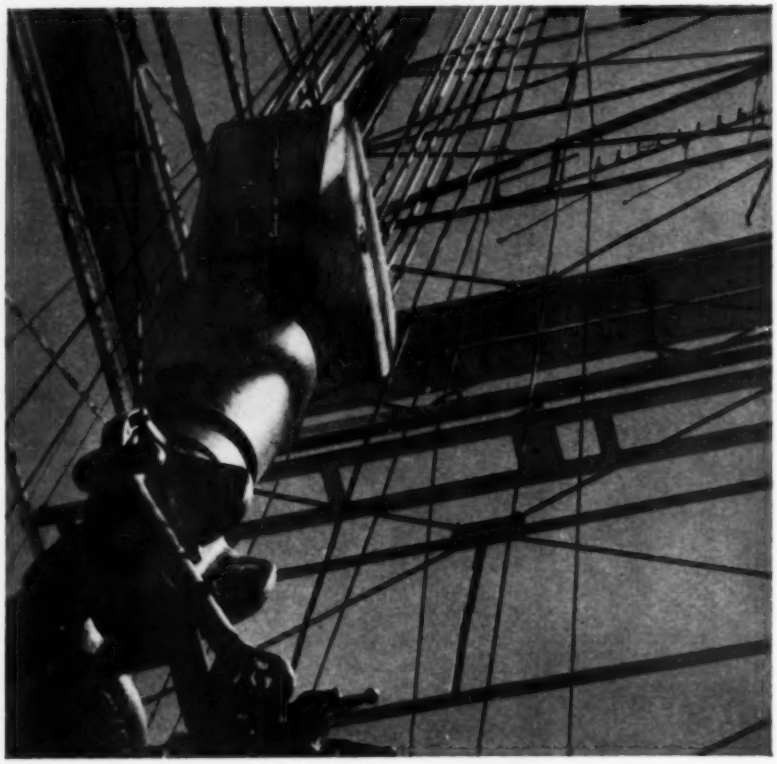
What is more important for efficient, economical drilling and completion than your mud and cement programs?

Rig up for Lower Cost Drilling and Completion... with DRISCOSE* and DIACEL**



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Profit from the continuing development work done in our laboratories as well as from the assistance of our experienced field engineers. Our knowledge of up-to-date techniques can help you keep drilling and completion costs at a minimum.

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WITH THE NEW TRI-Y DIAMOND BIT

. . . . . another D&S design advance for faster, deeper drilling . . . . . .

Again D&S sets the industry pace with new TRI-Y design diamond bits. In pressure compacted sands and hard abrasive formations D&S has proved once more that advance engineering and custom designing give you faster penetration rates and maximum efficiency for less.

CHECK THESE PREMIUM FEATURES

- **Reduced diamond concentration allows maximum use of mechanical energy.**
- **New design eliminates center . . . allows it to crush and wash out through large side port — eliminates re-grinding center.**
- **Minimizes sticking hazard from mud wall cake.**
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WRITE OR CALL TODAY! One of our sales engineers will call on you and explain this revolutionary new Diamond Bit.

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Ultra Fine Diamond Equipment for the Oilfield

Wherever there is drilling . . .
Rib-Tops are 1st choice in V-belts

Gates Rib-Tops are the ONLY V-belts specifically designed for mud pumps. Their superior design and construction insure longer life . . . much lower belt replacement costs . . . and downtime is reduced to a minimum.

Yet Rib-Tops cost no more than ordinary belts of comparable ratings.

Both Standard and Super Rib-Tops are available at your oil field supply house.

Use *Super* Rib-Top for Your Toughest Drives

With 40% greater horsepower capacity, Super Rib-Top easily handles overloads. Fewer belts and narrower sheaves solve space and weight problems.

The Gates Rubber Company
Denver, Colorado

The Mark of Gates *Specialized Research*

No other V-belt has ALL these advantages

1. Stabilizing ribbed tops (U.S. Pat. 2548135) are exclusive with Gates. They dampen vibration, protect top of belt from damage, keep belt running smoothly over idler-equipped mud pump drives with no side whip.

2. Flex-Weave Cover (U.S. Pat. 2519390) A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer . . . increases belt life . . . more power available to machine.

3. Concave sidewalls (U.S. Pat. 1813698) Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1-A). Uniform contact means less wear on sides of belt . . . longer belt life.

4. Tougher, more resilient cords are able to absorb the severe pulsations of mud pumps; easily handle peak loads.

TPA-401

Gates Rib-Top Vulco Rope

DEVELOPED ESPECIALLY FOR MUD PUMP DRIVES

See you in Tulsa, at the I.P.E., May 14 to 23, Booths 9 and 10, Texas Building

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

The Paul Bunyan of the Oil Fields

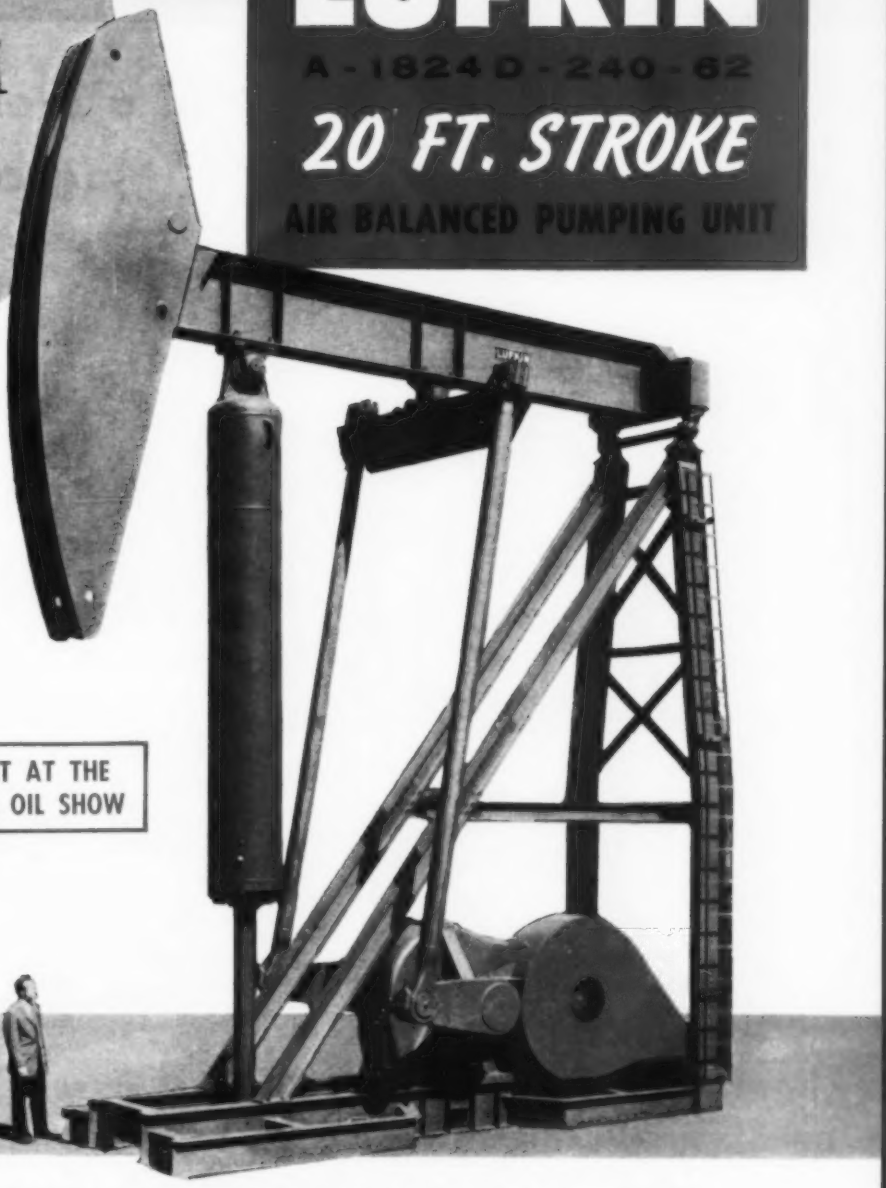
THE MIGHTY

LUFKIN

A-1824-D-240-62

20 FT. STROKE

AIR BALANCED PUMPING UNIT

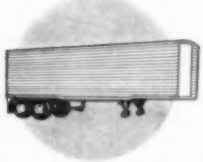


- Peak Torque — 1,824,000 in. lb.
- Stroke — 240 in. maximum
- Polished Rod Capacity — 62,000 lb.
- Overall Height *(top of stroke)* 46′-10″

SEE IT AT THE TULSA OIL SHOW

PUMPING UNITS

GAS ENGINES



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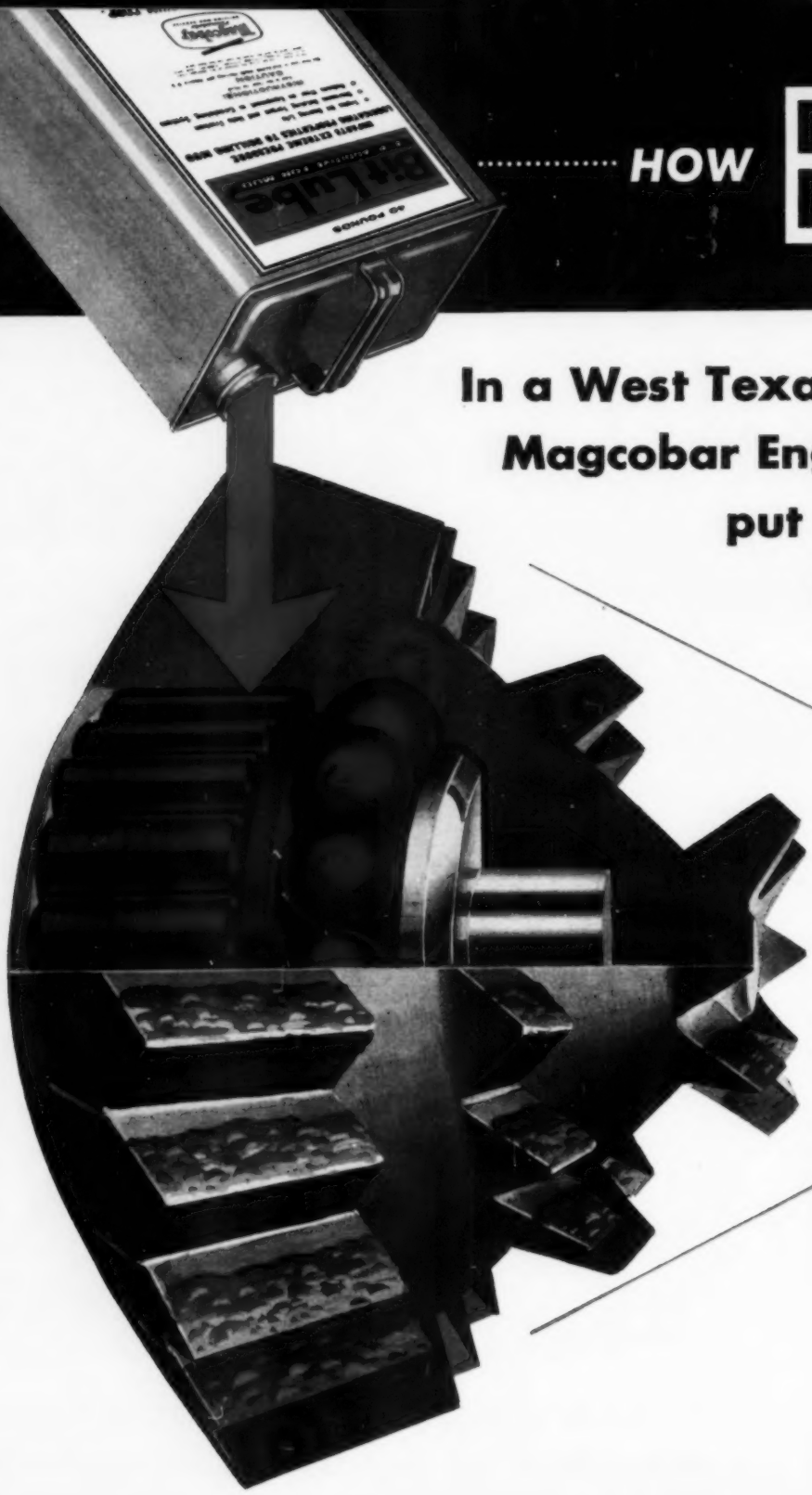
Lufkin equipment in Canada is handled by THE LUFKIN MACHINE CO., LTD., 9950 65th Avenue, Edmonton, Alberta, Canada, Regina, Saskatchewan, Canada

HOW BIT

In a West Texas Well, Magcobar Engineers put a film here.....



Another Well Done *with*

LUBE AND MAGCOBAR ENGINEERING CUT DRILLING COSTS

You are always sure of getting every cost-cutting advantage with Magcobar. Here's why: The Magcobar Mud Engineer combines a thorough knowledge of drilling fluid chemistry with experience in your drilling area. This background—plus the top mud lab in the country—gives new dimension to the finest and most complete line of drilling mud products. What does this mean to you? The highest level of product performance to cut your drilling costs.

..... to make net savings of $4.87 per foot

Here's proof of actual savings using Bit Lube (E. P. Additive for Mud). The table below shows a drilling cost comparison in the Brownfield, Texas, area. The Bit Lube well was drilled for $4.87 per foot less than the offset well.

	NO. BITS	BIT SIZE	INTERVAL	ROTATING HOURS	WEIGHT ON BIT	RPM
BIT LUBE-WATER	28	7⅞"	4919-7272	185	70-90,000	60-80
WATER	40	7⅞"	4936-7270	379	45-60,000	55-60

Total savings in bits, trips, and drilling time was $13,420. Bit Lube and emulsifiers cost $1,940; a net saving of $11,480!

Bit Lube forms a tough protective film to reduce friction and to increase bit bearing life under extreme pressure conditions. It works best with high weight on the bit and fast rotary speed. Bit Lube and Magcobar engineering may be the answer to your bearing failures.

Bit Lube is only one of Magcobar's many answers to the problem of high drilling cost, a problem that demands the right answers. You'll find that the right products *used right* by Magcobar can cut costs on your next well, too.

Magcobar
Complete
DRILLING MUD SERVICE

MAGNET COVE BARIUM CORPORATION
HOUSTON, TEXAS

59-200

Magcobar Technology !

MOST IMPORTANT ADVANCES IN PUMP DESIGN IN 30 YEARS!

WHELAND *PLANETARY* HP-16000 SLUSH PUMP

DUPLEX POWER SLUSH PUMP 7¾" x 16"
600 HP at 65 RPM

U. S. Patent 2,649,988 and 2,717,186. Other patents pending.

NOW! **FOR THE FIRST TIME . . .**
these proven mechanical principles are applied to a slush pump!

- **PLANETARY GEAR SYSTEM**
  with gear cartridge assembled and inserted as a unit.
- **CROSSHEAD IS A PERFECT CIRCLE**
  thus stays perfectly aligned in every direction.
- **FLOATING INPUT SHAFT**
  with unique sheave mounting which lets shaft transmit torque load ONLY.

SEE OUR EXHIBIT

MAY 14-23, 1959
Tulsa, Oklahoma

Three years in designing, developing and in final field testing are behind this newest, most advanced WHELAND 16" PUMP. A folder giving the highlights of this new pump is yours for the asking . . . or we can give you current locations so you can see it in operation. You can't afford to buy any pump in this size until you've seen this new Wheland pump!

WHELAND
ROTARY DRILLING MACHINERY

THE WHELAND COMPANY
CHATTANOOGA, TENNESSEE, U.S.A.

DRAW WORKS • SLUSH PUMPS • ROTARIES
CROWN BLOCKS • TRAVELING BLOCKS • SWIVELS

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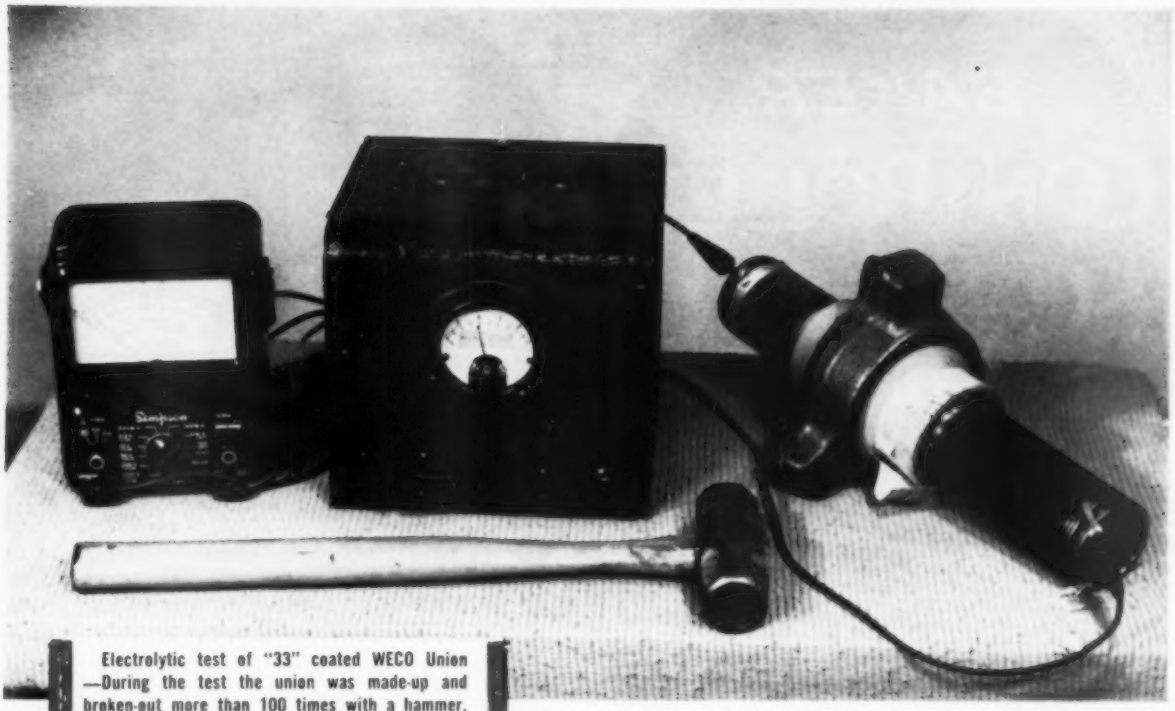


Electrolytic test of "33" coated WECO Union —During the test the union was made-up and broken-out more than 100 times with a hammer, without destroying the electrolytic protection.

CORROSION RESISTANCE!

Unretouched photos of unions subjected to an offshore water splash test for several months. Notice the protection afforded by the "33" coating.

COATED

UNCOATED

U-2-59

NOW... Any WECO Union Available Fully Insulated

WECO UNIONS in any size or pressure rating are now available, fully insulated, at a very nominal additional cost. Our amazing new "33" coating, applied by special process, internally and externally, to both subs and wing nut provides high resistance to electrolytic action. Completely coated, there is no conductive metal-to-metal contact between any parts of the union.

"33" coating is tough and flexible . . . fully tested in the laboratory and field. WECO Unions with "33" coating have been made-up and broken-out hundreds of times without destroying electrolytic protection through the union.

In addition to its electrolytic resistance, "33" coating protects against the corrosive action of line fluids, external vapors and atmospheric conditions in a multitude of services. WECO UNIONS with "33" coating are ideal for offshore installations, refineries, fuel storage systems and many other applications requiring internal as well as external corrosion protection.

See your WECO representative or visit your supply store for WECO Unions with "33" coating to protect against electrolytic action and corrosion. To specify WECO UNIONS with the "33" coating, simply add "33" to the figure number of the WECO Unions you want.

WECO

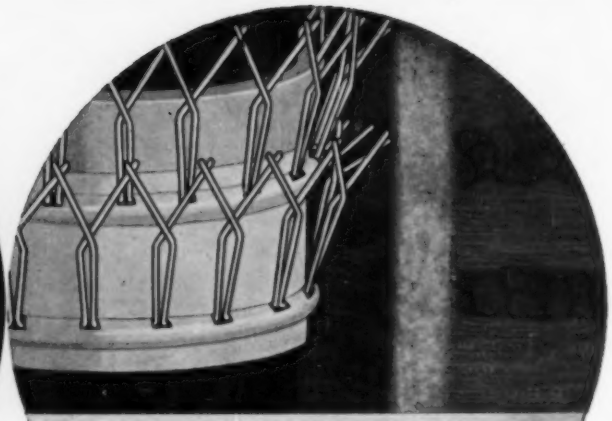
WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS

Division of CHIKSAN COMPANY a subsidiary of FOOD MACHINERY AND CHEMICAL CORPORATION

fmc

BAKER CONTROLLED SCRATCHING

OFFERS MORE THAN EFFECTIVE MUD CAKE REMOVAL

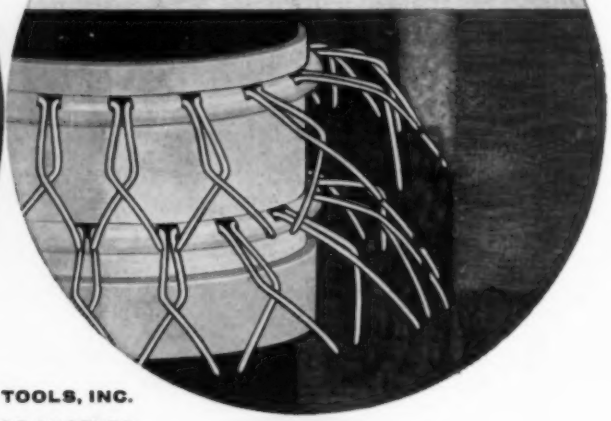


When the casing is being lowered, the scratcher wires swing freely upward and do not remove mud cake which can plug the annulus and cause dangerous pressure surge build-up.

BAKER

After reaching the area to be cemented, the hinged scratcher wires extend to contact the wall of the hole. and when the casing is reciprocated...

...scissors-like operation of the overlapped wires—over the full circumference of the well bore—effectively removes the mud cake which is circulated safely out of the hole.

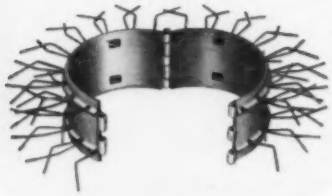


BAKER OIL TOOLS, INC.
HOUSTON/LOS ANGELES
NEW YORK

Controlled Scratching not only means more effective mud cake removal for a better cementing bond, but protects against destructive pressure surges while running casing. Baker Scratchers supplement the pressure-reducing performance of Baker FILL-UP Equipment, and the superior centering action of Baker Casing Centralizers, to provide *more* than a good cement job.

The Baker representative, and your supply store are ready to serve you.

Baker Wall Scratchers are available in the "Solid-Ring Type, (Product No. 901-C) which are slipped *over* the casing; and the "Hinge-Lok" (Product No. 900-C) which fastens *around* the casing. Both types can be positioned with either Solid or Split-Ring Baker no-weld Stop Rings to avoid harmful welding on casing.



THE ATLANTIC LECTURES OF THE UNIVERSITY OF TEXAS

PART 7

CORROSION: Holes in the Oil Industry's Pockets

The oil industry pays a staggering sum . . . about 2 billion dollars . . . every year in the never-ending fight against corrosion

Henry A. Stiff, Jr., *Senior Chemical Engineer*
Atlantic Refining Company, Dallas, Texas

THE DIRECT ANNUAL COST of corrosion in the United States for all industry has been conservatively estimated at $5.5 billion. This is a lot of money even in these days of inflated finances. As a matter of fact, corrosion costs rank with government costs as one of our major national expenses. For example, corrosion costs topped the $5 billion the Federal Government spent on its agricultural program in 1957 including the purchase of innumerable pounds of butter, oceans of wheat and the administration of the entire Department of Agriculture. Corrosion cost more than the $4.7 billion spent in operating our Veterans Administration with all its hospitals, insurance, and other benefits for the men who fought our wars. The cost of corrosion exceeded by 1½ times the money allocated to Foreign Relief. While we sent $3.9 billion worth of our nation's gold to our foreign neighbors, $5.5 billion worth of our steel rusted away at home.

The Rusting Fortune

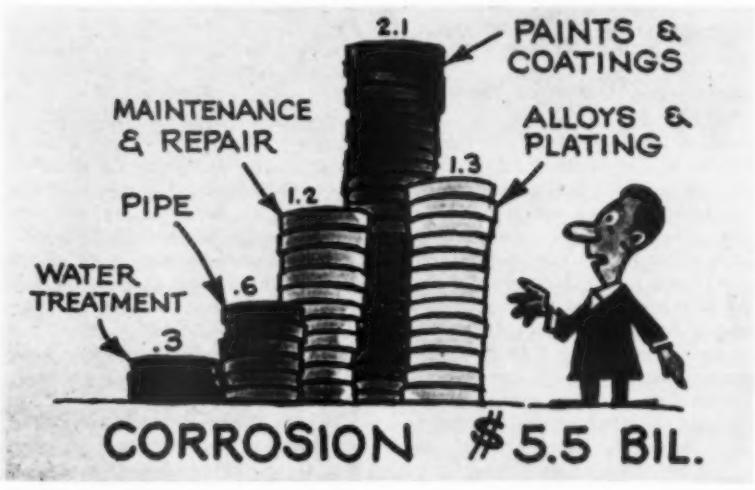
Let us examine some of the items in the corrosion bill that is annually presented to American industry, and ultimately paid for by John K. Consumer. Every year we spend about $2.1 billion for paints, coatings and their applications. Alloys, galvanizing and plating cost us another $1.3 billion while the maintenance and repair of operating equipment runs to $1.2 billion. The repair and replacement of pipe costs $.6 billion, and water treatment, including the replacement of boilers and heaters, cost another $.3 billion. These are the direct costs of corrosion, but this figure, as impressive as it is, does not include the many indirect costs which in most cases exceed the direct costs by a considerable margin.

Related costs. In one instance, corroded tubing was recently replaced in one of the large oil refineries. The cost of the replacement was $1500, but an additional 72 hours of production was lost at $800 an hour. Thus the indirect cost of corrosion was $57,600, while the direct cost was only $1500. In another instance, a corroded condenser in a public utility plant was repaired for $2500. As a result the power plant had to be shut down for five days and power purchased from another source at $1000 a day. The cost of the power makeup was $5000 while the cost of the corroded condenser was only $2500.

In the oil industry indirect costs are astronomical. When a string of tubing in an oil well several miles deep corrodes and parts, a costly fishing job may result. Corrosion of wellhead equipment on high-pressure gas wells can result in dangerous blowouts. In one example a Christmas tree corroded and failed on a high-pressure gas well. The Christmas tree cost only $3750, but the fire which resulted cost over $2 million.

Corrosion is a high cost item in the oil business. One authority estimates it amounts to about $2 billion or 36 percent of the total corrosion costs of all industry. This estimate seems a little high, but if we consider again our annual corrosion bill we can see that the oil man certainly pays his share.

The first item shows that over $2 billion was spent on paints and coatings. Because of the corrosive nature of fluids handled in the oil business and



because of the location of producing operations in all types of environment including salt water, a large share of the paint and coating bill is borne by the petroleum industry. Likewise, metallic alloys find much use in the oil business and we bear a large share of the $1.3 billion spent in this category. Our underground pipe maintenance and replacement bill makes up a considerable portion of $.6 billion spent for this item and we also contribute substantially to the $1.2 billion spent for the repair and maintenance of operating equipment, which includes our refineries and transportation facilities.

The production, handling and disposal of salt water is also a big problem in the oil business, and this accounts for a good part of the $.3 billion spent on corrosion in this category. From this it can be seen that while corrosion is not the exclusive burden of the oil man, he is at least called upon to contribute substantially to its annual cost. And in addition to the direct costs, the indirect costs of the petroleum industry are particularly high. Over design of equipment is standard procedure due to the risk involved. Shut-ins and fishing jobs are extremely costly, and fires and blowouts are a constant danger.

Industry-wide problem. All sections of the petroleum industry are susceptible to corrosion problems. In exploration there are hundreds of thousands of dollars worth of delicate instruments which are frequently exposed to severe environmental conditions.

In drilling operations, corrosion and stress cracking of the drill stem may cause heavy losses, and the indirect cost is high, as costly fishing operations and loss of holes can quickly run into considerable money.

The pipeliner asks for trouble the moment he puts pipe into the ground and has to take elaborate precautions to prevent corrosion leaks which could result in loss of product, fires, or explosion.

In refining operations, natural gasoline, petrochemicals and sour crudes, together with the high temperatures and pressures involved, make corrosion a big problem and increases greatly the risk of fire and explosion.

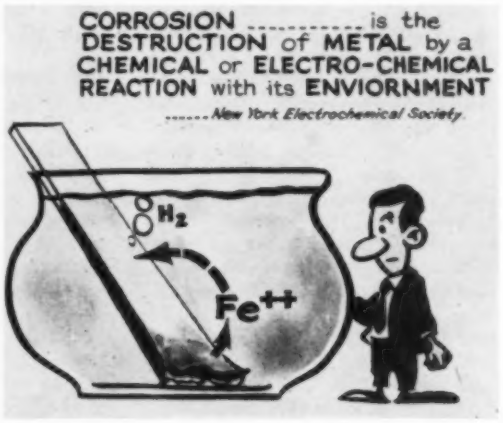
In marine operations, salt water and air team up to corrode tankers and barges, and in marketing, the storage and service facilities must be protected inside and out against chemical and atmospheric corrosion.

Leaks around a gasoline storage tank can not only result in serious loss of material but can be very dangerous fire hazards as well.

In the producing department, however, the oil man faces his greatest corrosion problem. His equipment consists mainly of oil wells containing miles of pipe, some of it extending as much as 20,000 ft into the earth. Every inch of this pipe is potentially subject to corrosion. Within the wells and on the surface are expensive pumps which can be wrecked by corrosion. Sucker rods extend thousands of feet into the holes and are subject to alternate tensile and compressive stresses. Fluids handled are often extremely corrosive.

Gas pressure can run as high as 10,000 to 15,000 psi. Failure of a valve or wellhead connection may cause an expensive blowout or fire with resulting losses of millions of dollars. Offshore operations have caused corrosion costs to soar. The effect of the winds, of the salt water and the weather has caused a tremendous increase in corrosion problems. One authority estimates that over $2 million annually is spent for paint alone on the offshore platforms in the Gulf Coast.

Definition of corrosion. Perhaps a good definition of corrosion is in order. There are a number of definitions in literature, but the most widely accepted is that sponsored by the Electrochemical Society of New York. This states that "corrosion is the destruction of a metal by a chemical or electrochemical reaction with its environment." Corrosion is an electrochemical reaction and takes place because of the flow of electricity between an anodic area (or anode) on a piece of metal and a cathodically charged area (or cathode). The metal goes into solution at the anode and hydrogen gas is evolved at the cathode.



A little less technical is the reservoir engineer's definition of corrosion. He states that "corrosion is a process of nature designed to increase the horizontal permeability of the casing."

Determining Corrosion Damage

The first corrosion problem that the petroleum engineer faces in the oil business is that of recognizing corrosion. He must not only be able to determine whether or not corrosion is taking place in certain installations, but he must also be able to determine its probable extent, how much it has cost in the past and how much it is going to cost in the future. If the well has not yet been drilled, he has to determine how much corrosion is likely to take place and how much the cost is going to be. He has to do all of these things before he even considers the type of corrosion which is involved or the method of controlling it.

Fortunately, this is not as difficult as it sounds. If it were, there probably would be fewer engineers in the corrosion business or fewer corrosion engineers in business. There are methods of recognizing corrosion, of determining its extent and, to a certain degree, predicting how much it is going to cost in the future. None of these methods is perfect but a lot of them work.

The oil well is the fundamental unit of petroleum production. It is not only the most expensive unit in this phase of operations, but it is located where most of the costly corrosion problems occur. The mere fact that corrosion is taking place two miles beneath the earth's surface naturally adds considerably to the cost of doing something about it. Therefore, most of this discussion about corrosion in the oil business (which we have already limited to producing operations) will be further confined to corrosion in oil wells.

Well history. The first method to be considered for recognizing corrosion is the study of the well itself, or the "well history." Since the oil well is the fundamental unit in producing operations, most oil companies keep rather complete records on their wells. If a well has been in operation for a considerable time, it is usually possible for an alert engineer to detect trends which indicate unduly heavy replacement costs due to corrosion. He must be able to distinguish corrosion costs from costs that are due to failure of equipment from some other cause. Unfortunately, this distinction is not always clear, but by diligent study of the well history and proper evaluation of supplemental data together with a lot of "alertness", it is often possible to make a good estimate of future corrosion costs.

When well histories are not available, the engineer frequently can use field histories to estimate the corrosion costs.

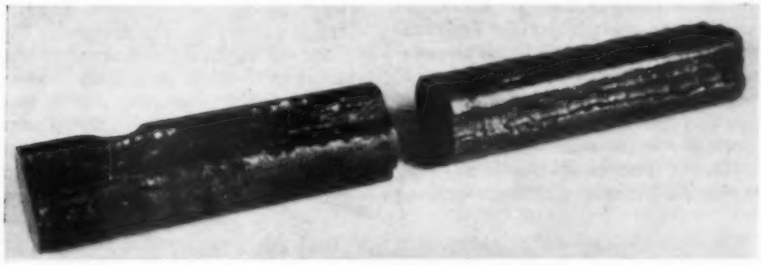
Often his company does not begin to exploit its holdings until development of a particular area is well advanced. In such cases, the engineer has to rely upon experience of other operators in the field. This is where contacts become important and is literally a case of not what you know but who you know. For this reason, cultivation of "reciprocal trading arrangements" insofar as corrosion information is concerned pays off handsomely for everyone.

To this end the technical societies, such as the National Association of Corrosion Engineers and the American Petroleum Institute, contribute a good deal of time and effort. Both the engineer and his company usually cooperate in these efforts to the fullest extent of their facilities.

Visual observation. In addition to a study of well records, the engineer can learn a lot by visual observation. By periodically inspecting the Christmas tree fittings, meter runs, flow lines, chokes, valves, etc., valuable evidence in defining the corrosion of a well can be obtained, particularly during the early stages of an attack.

In condensate wells, the well choke is often subject to corrosion, and is usually readily accessible for examination. An irregular surface attack is typical of the so-called "mesa" type of corrosion. Here a hard enamel-like surface film retards the corrosion in some spots while the absence of such film allows it to proceed in others.

On pumping wells the sucker rods, particularly the couplings, give valuable indications of corrosion. They can be examined when the rods are pulled



and the extent of the corrosive attack can be readily seen.

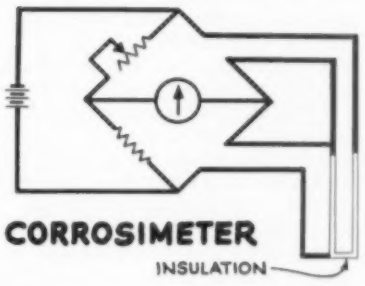
Very often it is possible to cut into a joint of the tubing, so that the location of pits and various other manifestations of corrosion can be determined. The pitting which frequently occurs on the tubing in sweet oil wells is due to the build up of scale deposits. The area beneath the scale becomes anodic with respect to the surrounding surface, a current flows, and corrosion results. "Ringworm" corrosion occurs at the tubing upsets as a result of failure to relieve internal strains by proper heat treatment. The "strain" areas being different in metallurgical structure become anodic with respect to the rest of the tubing and corrosion takes place.

Although the data yielded by visual inspection often indicate severe corrosive attack, the absence of corrosion in surface equipment is not always an indication of a lack of corrosion in the well. It is not uncommon for severe corrosion to be present in the subsurface equipment where no surface attack is detectable. Therefore, visual examination should always be supplemented by other methods.

Coupon test. In addition to studying the well histories and inspecting the equipment, the engineer can make certain tests which indicate the probable extent of the corrosion. One of the oldest and best known of these tests is the coupon. Small metal plates, usually cut from mild steel, are weighed and exposed to the well fluids for a period of about a month. They are then cleaned of corrosion products and reweighed. The difference in weight gives loss of metal due to corrosion. In order to compare the results of coupon tests, the data are usually expressed in terms of inches penetration per year. The "IPY," as it is called, is equal to the weight of metal removed divided by the product of the density of the metal times the area of the coupon times the years of exposure.

In gas wells, coupon data seem to correlate especially well with the corrosion history. In one survey where the coupons had about .01 IPY, the well histories all showed evidence of corrosive attack, and equipment replacements were frequent. In wells which required less frequent replacement, the average coupon corrosion rate was .005 IPY. In wells showing no history of corrosion damage, the coupons indicated a corrosive attack of less than .001 IPY.

Electrical "corrosimeter." An elaboration of the coupon system has recently been developed. This is called



the electrical resistance or "corrosimeter" method. A wire probe, placed in the corrosive environment, is connected to a "bridge" circuit so that the electrical resistance of the insulated side of the probe can be balanced against resistance of the uninsulated side. Corrosion of the exposed wire leads to a decrease in the cross sectional area, and therefore an increase in resistance. By exposing both halves of the probe to the same conditions, temperature effects are minimized and an indication of the corrosive conditions can be obtained.

The electrical resistance method has several advantages. By using a wire of small diameter, the sensitivity of the measurement can be greatly increased, and an indication of the corrosion rate can be obtained in a much shorter time than by using a coupon. Another advantage is that curves showing the corrosion rate can be plotted without removing the probe from the environment. This is of particular advantage in studying the formation of films where the corrosive rate is high at the start but gradually decreased as the protective film is built up.

Tubing calipers. Tubing calipers pro-

vide a very useful tool for determining the extent of corrosion, especially since they can be used in wells under pressure. These instruments operate by recording the movement of feelers which bear against the inner surface of the tubing. A chart results from which it is relatively a simple matter to estimate the extent of corrosion. Pits, general corrosion, and so-called "ringworm" corrosion can be determined. If the history of the tubing is known, caliper surveys taken at periodic intervals make it possible to make a good prediction of the life of the tubing.

Chemical analysis of fluids. Another method upon which estimates of corrosion costs can be based is the chemical analysis of the well fluids. Since steel is generally used for tubing in oil wells, the iron content of the produced fluids indicates the amount of iron lost from the tubing due to corrosion. However, iron is frequently a normal constituent of formation water, so it is often necessary to establish a base line iron content which denotes the level at which corrosion is at a minimum. When this base line is exceeded, corrosion is taking place.

In a study of a number of gas wells it was found that the average iron content of the corrosive wells was two or three times larger than that of the non-corrosive installations. As a rule of thumb water from non-corrosive wells usually contains less than 50 parts per million iron while that from corrosive wells is over 50. An important determining factor, however, is the amount of water produced. The concentration of iron naturally becomes less as the well produces more water. For this reason, iron contents are frequently evaluated in terms of pounds of iron lost per day instead of parts per million.

Formerly, it was believed that all the iron in well fluids was present in the water phase. Recent investigations, however, have shown that organic iron compounds are frequently present in the oil phase. For this reason, reliance on the iron content of the water alone often leads to erroneous conclusions. If total iron content of produced fluids is known and fluid production is known, then total iron loss can be more accurately calculated and a better estimate of the corrosive condition in the wells can be obtained.

The operating conditions of the well often furnish strong indications of corrosion. Presence of hydrogen sulfide or carbon dioxide in well gas generally denotes that corrosion will take place. Excessive amounts of free carbon dioxide and organic acids in the water also predispose wells to corrosion. The oil-water ratio, the rate of production, and the method of production are also important factors which have a bearing on whether a well will corrode.

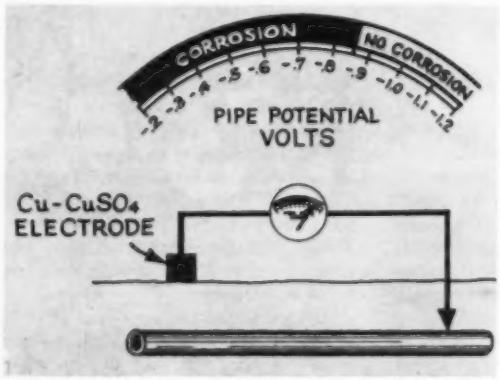
In gas condensate wells, the principle cause of corrosion is carbon dioxide which dissolves in produced water to form carbonic acid. Probably the most significant corrosion factor in condensate wells is the partial pressure of the carbon dioxide in the gas. It will be recalled that a gas exerts a partial pressure equal to its percentage concentration times the total pressure of the gas mixture. Thus in a well containing 1 percent carbon dioxide at 1000 psi, the CO_2 has a partial pressure of 10 lb per sq in. A partial pressure of less than 10 psi generally causes no corrosion. Below 30 psi it is significant.

In general, the conditions necessary for potentially corrosive gas condensate wells have been fairly well worked out. If a gas condensate well falls into one or more of the following categories, there is a good possibility that it will be corrosive.

1. Depth greater than 5000 ft.
2. Bottom-hole temperature in excess of 160 F.
3. A bottom-hole pressure in excess of 1500 psi.
4. Production rate in excess of 2 MM cu ft per day.
5. Carbon dioxide partial pressure greater than 30 psi.
6. A pH of less than 5.5 in the wellhead water.

Electrical measurement. Since corrosion is an electrochemical phenomenon, there are naturally electrical methods which at least give an indication of the probable extent of corrosion. These are nearly all used to measure external corrosion on buried pipe, such as in pipelines, but to some extent are also used to measure external casing corrosion in oil wells.

One of these methods involves measuring the potential difference between the pipe and a copper-copper sulfate electrode in contact with the ground. It is frequently used to measure the efficiency of cathodic protection where a potential more positive than −.85 volts on the pipe indicates conditions favorable to corrosion.



Another interesting method is the so-called "potential profile" survey. In this method a tool is lowered into the well and the electrical potential measured between points 25 ft apart on the interior wall of the casing. In accordance with our definition, areas where corrosion is taking place will be anodic with respect to the rest of the casing. Thus by measuring the potential difference between the two points over the entire length of casing, a "potential profile" can be obtained from which an estimate of corrosive conditions of the casing can be made.

When the engineer has made his estimate of the extent of corrosion and calculated its probable costs, his job is only half done. The hardest part is yet to come. He must now try to select some way of controlling the problem which is cheaper than the corrosion itself. The difference between the cost of the uncontrolled corrosion and the amount spent on its control constitutes the economic justification for his job. There is no general method of controlling corrosion that will prove satisfactory for all installations. Each method has to be selected and evaluated on its merits in relation to a particular installation in order to obtain satisfactory results.

Control of Corrosion

Materials selection. The most fundamental method of controlling corrosion is to use materials which resist the corrosive attack. Certain alloys are resistant to various types of corrosion. For example, high chromium and high nickel steel alloys are effective where no salt water is produced. This type of alloy, however, seems highly susceptible to salt water attack and in general cannot be used when the well is producing salt water. The heat treatment to which an alloy was subjected is also very important, as this, to a great extent, determines its hardness.

If the metal is too hard it may be susceptible to stress cracking, which although not strictly corrosive in nature, is somewhat related. In this type of attack, hydrogen evolved from acid solutions penetrates the metal and causes embrittlement, then cracking results when the metal is sub-

jected to stresses which are below the normal yield point. Stress cracking is one of the problems now frequently being encountered in high pressure, high temperature gas wells and a great deal of metallurgical study is being done in trying to control it.

Protective coatings. Another corrosion control method is the use of protective coatings. Everyone is familiar with the various metallic types of coatings, such as galvanizing, nickel plating, chrome plating, etc. Most of these, with the possible exception of galvanizing, have not been too effective in oil field use, largely because of the cost. Galvanizing is frequently used on surface equipment such as tanks, etc., but it finds very little application in the hole. The same is true of most of the other inorganic coatings such as cements and ceramics. Cement lined surface pipe is sometimes used in water disposal operations and occasionally ceramic or glass coated installations can be found.

The majority of the coatings used in the oil industry are of the organic type such as paints or plastics. In the last few years, plastics such as phenolics and epoxys have been used to coat tubing. The interior surface of the tubing is coated with a thermo-setting resin at the factory and then baked. Such a coating often offers a satisfactory solution to a corrosion problem which cannot be handled effectively by other methods. The baked phenolic type plastic is extremely hard and resistant to abrasion, but it is fairly brittle and somewhat susceptible to alkali attack. The baked epoxy resins on the other hand are more resistant to alkali and less brittle, but being softer they do not resist abrasion as well.

In recent years a number of dual coatings have appeared. Usually these consist of several layers of baked phenolic which are then overlaid with layers of baked epoxy. This combines the more favorable properties of both resins.

A new plastic, polyurethane, has recently made its appearance as a coating and seems to offer some promise.

Wrapping and coating the exterior surface of the pipe with asphalts, tar, and epoxy compounds find application in pipeline work, but due to the difficulty of running the strings, has not so far been used extensively in the holes. Paints of all sorts are commonly used on the surface but find very little application in the hole.

Chemical inhibitors. Inhibitors are organic compounds which form a temporary film on the surface of a metal and insulate it from corrosive environment. Two difficulties are inherent in the use of inhibitors. One of these is the selection of the best inhibitor for use in a particular environment, and a second is getting the inhibitor to where it is needed.

A great deal of time and effort has been devoted to the evaluation of inhibitors in the oil industry. In general, the methods used can be divided into two classes — the static and the dynamic. The most common static method is to place a weighted steel coupon in a flask containing salt water to which air and hydrogen sulfide or carbon dioxide have been added. After exposure for several days, the coupon is removed, cleaned and weighed and the "IPY" calculated by the method previously given. At the same time, duplicate flasks containing varying concentrations of inhibitor are also run. From these data the percentage of protection afforded by the inhibitor can be estimated.

Conditions in the well, however, are seldom static. In addition to fluid movement, pressure and temperature also affect the corrosion rate and high temperatures and pressures are frequently encountered. For this reason, various dynamic tests have been devised. Most of these are modifications of the flask coupon method to which some system of controlling the temperature and pressure is provided together with the means of agitating the fluid.

One of the more recent dynamic inhibitor tests consists of a cylinder within which a constant temperature can be maintained. Steel containers are secured into holes in the cylinder, and pressure can be applied if the situation indicates. Instead of a coupon, a corrosimeter probe is built into each container so that measurements of the corrosive condition can be made without unsealing the container or removing it from the hole. On this equipment the temperature, pressure and corrosive fluid can be made analogous to those encountered in the well, and data can be secured upon which a suitable inhibitor can be selected.

Cathodic protection. Another method of controlling corrosion is the use of cathodic protection. As stated in our definition, corrosion is an electrochemical phenomenon. If we connect a piece of iron and a piece of copper through a wire and place these metals in a salt solution, the iron will corrode due to the electro-chemical reaction which takes place. Molecules of iron dissolve and go into the salt solution leaving electrons behind. These electrons travel through the wire to the copper plate. Positive hydrogen ions in the water migrate to the copper where they pick up electrons and pass off as hydrogen gas. The copper plate, then, is the cathode and the iron plate the anode. Loss of metal takes place from the anode while a build-up of decomposition product from the electrolyte solution occurs on the cathode.

Anodic and cathodic areas are always present when the corrosion process is occurring, even in the case of a single metal. For example, if zinc is placed in hydrochloric acid, the hydro-

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gen bubbles which form on the surface indicate cathodic areas. Zinc ions pass into the solution from the anodic areas in the immediate vicinity.

An interesting experiment consists of placing an iron nail in a gel containing sodium chloride, phenolphthalein, and potassium ferricyanide. After a short time a pink zone develops around the shank of the nail because it is cathodic and the hydrogen ions which collect there react to the phenolphthalein. Blue areas developed around the cold worked head which is the point where the iron goes into solution from the anode and reacts with the ferricyanide.

Cathodic protection is a method whereby the metal to be protected is made the cathode with respect to an external anode. In this way any corrosion which takes place occurs on the "sacrificial" anode and the metal itself is protected. If a piece of zinc connected to the nail is placed in the gel, the blue areas will no longer form around the nail. The entire surface of the nail is rendered cathodic and is thus protected from corrosion.

Cathodic protection in actual practice consists of impressing a negative current on the metal to be protected. This may be done by generating such a current with a zinc or magnesium anode as in the case of the nail, or by applying direct current from an external source. Zinc and magnesium are the so-called sacrificial anodes most frequently used where the material to be protected is in direct contact with water, such as in the case of boats, barges, and offshore platforms. The common magnesium rod in a water heater is a sacrificial anode. Applied current is most frequently used in pipelines, oil well casings, and in other installations where large areas have to be protected.

In summation, we have seen that corrosion is an electrochemical process by which a metal is destroyed in reaction with environment. The first step in its control is to recognize it and determine its economic extent. In the production end of the oil business the probable economic extent of corrosion can be estimated by studying the well records, field histories and test data, and serving equipment.

Corrosion may be visualized as a lot of holes in the pockets of every operator in the oil business. Through these holes are lost millions of dollars every year which otherwise might have gone to our employees, stockholders and customers. The situation is not hopeless, however, for the engineer with training and experience in corrosion control can patch up many of these holes and keep his company's profits from flowing away. ★ ★ ★

Elected Southern District API Production Chairman, Albert L. Vittner, Jr., left, The California Company, New Orleans, is congratulated by retiring chairman, Roy A. Bobo, Phillips Petroleum Company, Houston, who was named chairman of the District Advisory Committee. District vice-chairmen present at the meeting held March 25-27 in New Orleans were from left, Paul Clinkenbeard, Dowell division of Dow Chemical Company, Shreveport, Ark-La-Tex area; W. J. Green, Delta Iron Works, Incorporated, Houma, southern Louisiana; J. J. Harper, Lane-Wells Company, Victoria, south central Texas; and Thomas Pennington, Humble Oil & Refining Company, Houston, Texas, Gulf Coast. Other district officers named but not shown were: Walter Kalteyer, Hunt Drilling Company, Corpus Christi, southwest Texas; Carl A. Kinney, Atlantic Refining Company, Lafayette, southwest Louisiana; Jack Robbins, Skinner Corporation, San Antonio, Balcones area; J. C. Brown, Sun Oil Company, Sullivan City, Texas, Rio Grande Valley area; Earl White, Mustang Drilling Corporation, Tyler, east Texas; and R. A. Buschman, Field Drilling Company, San Antonio, secretary-treasurer.

Highlights . . . Southern District API Meeting in New Orleans

WARM sunshine and beautiful flowers made New Orleans a most pleasant meeting place for the 825 registrants attending this meeting March 25-27. Nearly all those in attendance were optimistic about the possibilities of increased activity in 1959. There was much concern, however, about the problems presented by low allowables, increased costs and governmental interference.

H. C. Teasdel, president, The California Company, made a plea for higher allowables for offshore wells to bring this important producing area back into profitable operation. He also stressed safety of operations but called for care in setting up safety rules and regulations. Safety regulations should not make unreasonable demands that actually do not add anything to safe operation but which add measurably to the cost of this already too expensive operation.

Jerome M. Alper, Washington attorney, gravely warned of the growing control of natural gas by the government via application of utility and utility-type regulation. Damage to the natural gas industry in recent years from governmental interference will probably never be fully evaluated or overestimated.

L. E. Fitzjarrald, manager of production for the Phillips Petroleum Company, Bartlesville, Oklahoma, presented an excellent paper entitled "Ways and Means of Achieving Economy in Drilling and Production Operations." It was very comprehensive in scope covering drilling, well spacing, multiple completions and commingling, unitization, automation, standardization, corrosion, safety and public relations. Many other subjects were also touched upon and the paper is highly recommended for all personnel.

Fitzjarrald emphasized that rewarding individual accomplishment is still possible. He made a number of excellent suggestions which everyone should continually review for a maximum use of his most valuable possession . . . time. Unless a company has competent people there will not be wise planning, or effective use of existing and new equipment. People are a company's most valuable asset Fitzjarrald emphasizes and he closes with the reminder that "There's no limit to the good a man can do if he doesn't care who gets the credit."

Widespread interest in the many excellent papers presented was evidenced by the substantial group remaining through even the last paper presented. The Southern District officers and program committee personnel are to be highly congratulated on their excellent program and convention planning which resulted in an enjoyable meeting for all in attendance. ★ ★ ★

Efficiency and Economy Will Result From . . .

Engineered Hydraulic Fracture Treatments

Part 2, Conclusion

Davis D. Hunt and Horace R. Crawford
The Western Company, Midland, Texas

The equation for calculating fracture areas is reduced to graphical and nomographic solutions showing the effect of each variable on relative efficiency and economy

THUS FAR, an equation has been presented for calculating the area of fracture resulting from a treatment. This equation was found to include a coefficient C. This coefficient was a measure of the flow resistance of fluid which leaked out of the formation during the treatment. It related the differences in reservoirs and the differences in fracturing fluids to the area equation.

It is seen that, depending on the circumstances, C may take any of three forms. Each of these forms describes a separate mechanism tending to retard leak-off. In an actual treatment, each of these mechanisms operates to a greater or lesser extent. Any frac fluid has some viscosity, so the C_I mechanism helps retard leak-off even with a very slightly viscous fluid such as water. The reservoir always contains only slightly compressible fluid, thus the C_{II} mechanism always contributes. Many oils have some wall-building effect, even without an additive, so the C_{III} mechanism is usually present to some degree.

The segregation of treatment fluids in the discussion is based on this fact: One of these mechanisms will always be more effective than either of the other two. For a given case, the most effective one is considered to be the controlling mechanism. The most effective mechanism is the one which gives the lowest rate of leak-off; that is, the one which gives

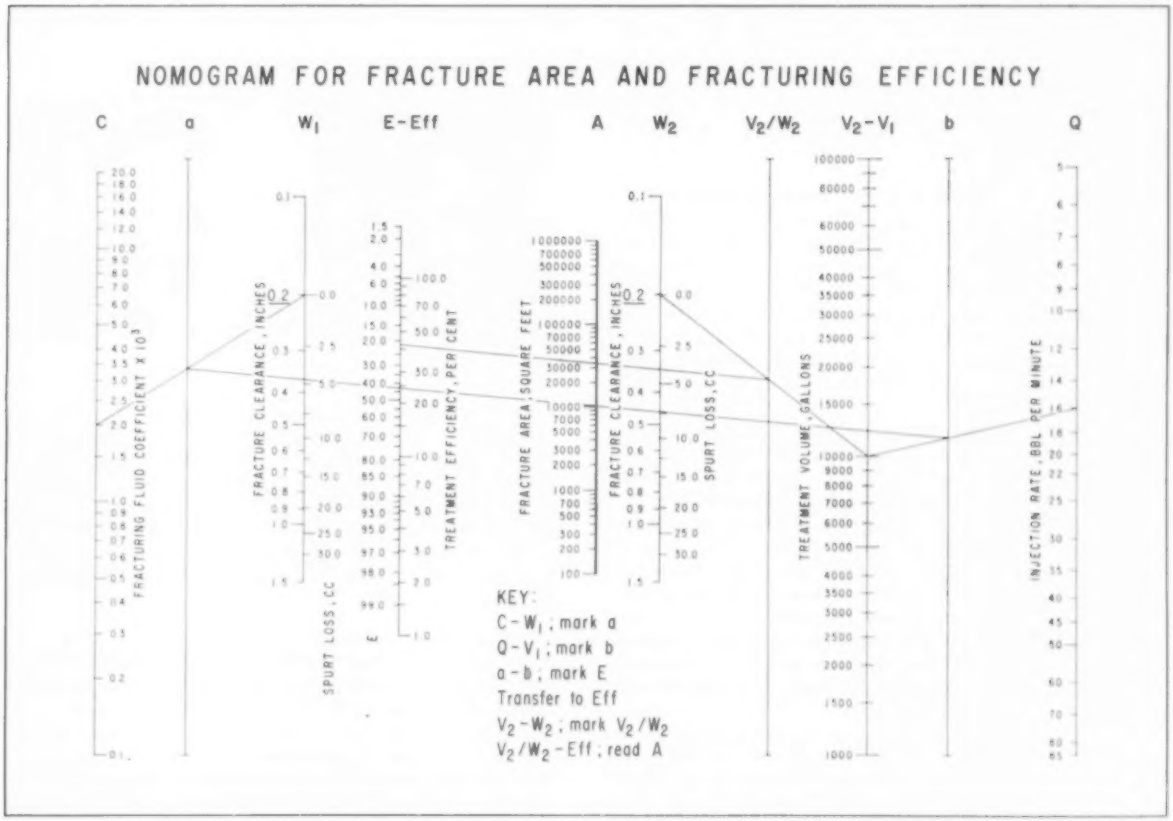

FIG. 5. Nomogram for determination of fracture area and fracturing efficiency involves the coefficient C, treatment fluid volume injection rate, and fracture clearance. Fracturing efficiency is an intermediate answer in the nomographic solution. A sample problem is illustrated on the chart.

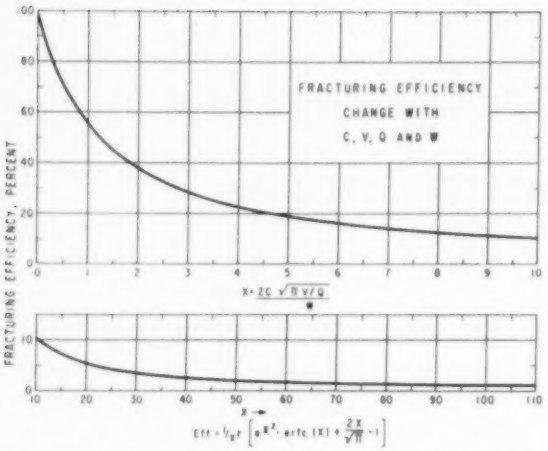

FIG. 6. Plot of fracturing efficiency against its function. This graph presents fracture volume as a percentage of treatment volume, for combinations of the four variables in the function.

the lowest C value. Thus, the lowest C value which can be calculated is the one used in determining the fracture area.

It is apparent from the foregoing statement that any calculation of fracture area by this method will be conservative to some degree since in any case two of the mechanisms have, in effect, been neglected. The calculation always gives a minimum fracture area.

To review, when a viscous fracturing fluid is used, C_I will normally be the controlling mechanism. When water or lease oil without additives is used, C_{II} will normally be controlling. When a fluid loss additive is used, C_{III} should be expected to control the leak-off rate. Of course, exceptions may be found to any of these three statements. In any case of doubt, simply calculate as many of the C values as necessary and select the lowest as the controlling mechanism.

Calculation of Fracture Area from Nomogram

Having determined the lowest C value, it is now possible to calculate the fracture area which may be obtained with the particular fluid. This is easily done by applying the variables of coefficient, fluid volume, injection rate, and fracture clearance to the nomogram illustrated in Fig. 5. It should be noted that the variables of volume and fracture clearance appear twice in the nomographic solution. Care should be taken to apply the same values for these two variables in each case.

It was stated earlier that it will usually be necessary to assume a fracture clearance, W. On the nomogram, 0.2 in. is indicated as the normal value of this variable. This is the value believed to be most nearly representative of a majority of wells. Higher or lower values may be taken if sufficient justification exists.

The fact that a fracture may have a different clearance from the 0.2-in. assumed value is not so serious as it may first appear. The primary concern is really with the relative effectiveness of various combinations of fluids, volumes and rates. As long as the assumed fracture clearance is within range of the true value, satisfactory appraisals can be made of the other variables.

The same sort of argument can be applied to the calculation of the coefficients, also. Here are included certain reservoir data about which there is usually some degree of doubt. But since relative values are really being sought, valuable results can still be obtained in spite of this uncertainty.

It was mentioned above that a technique was available for including spurt loss encountered with many fluid loss additives into the calculations. Examination of the area nomogram, Fig. 5, will reveal this technique graphically. The line for the variable, W, which appears twice in the nomogram, has a dual scale of cc spurt loss, with the 0 cc point at a W value of 0.2 in.

Mathematical basis for this scaling is quite simple. The experimentally determined spurt loss is taken into the calculations as an assumed equivalent increase in fracture width, W. The charted scale, of course, assumes a filter medium area of 22.8 sq cm and a true fracture clearance of 0.2-in. If necessary, the scale may be adjusted for other values of these two factors.

Calculation of Fracturing Treatment Efficiency

Note that one of the intermediate lines on the fracture area nomogram is labeled *Efficiency*, as a percentage. This intermediate answer in the nomographic solution is actually the percentage of the fracturing fluid remaining in the fracture at the end of the treatment. The physical worth of the treatment, i.e., the area of fracture created, of course requires completion of the solution. However, this efficiency term is a measure of the worth of the treatment combination in terms of fracture per unit volume of fluid.

A plot of fracturing efficiency versus its function, $x = \frac{2C\sqrt{\pi V/Q}}{W}$ is presented in Fig. 6. Fracturing efficiency is defined by the equation:

$$\text{Area of fracture} = \frac{\text{Volume of fluid pumped}}{\text{Width of fracture}} \times \text{Efficiency}$$

Fracture Area Charts

Graphical representations, Fig. 7 and 8, have been made for two selected values of the coefficient, C. On these graphs

D. D. Hunt

H. R. Crawford

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Horace R. Crawford *is a research associate for The Western Company at Midland, Texas. He received a B.S. degree from Texas Technological College in 1949. He received M.S. and Ph.D. degrees in chemical engineering from the University of Texas where he also taught mathematics. During the Korean conflict, he was an instructor in the Far East Command Radiological Defense school. He worked for Sun Oil Company for more than two years, variously as an engine operator, gas tester, plant chemist, junior petroleum engineer, and gas engineeer. He is a member of the AIChE, AIME, and Sigma XI.*

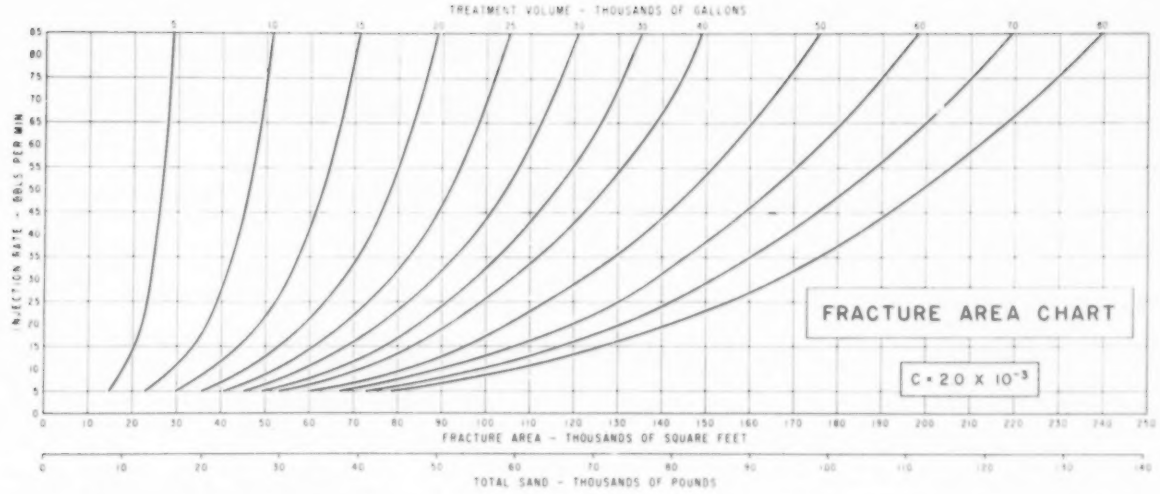
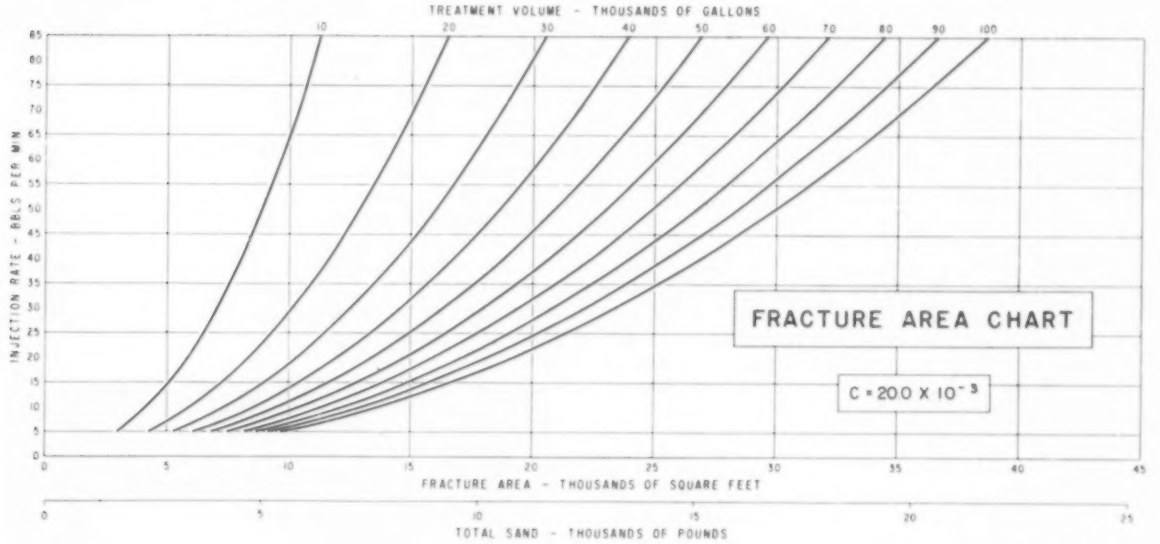

TREATMENT VOLUME - THOUSANDS OF GALLONS
INJECTION RATE - BBLS PER MIN
FRACTURE AREA CHART
C = 2.0 X 10⁻³
FRACTURE AREA - THOUSANDS OF SQUARE FEET
TOTAL SAND - THOUSANDS OF POUNDS

FIG. 7 (above) and FIG. 8 (below) are graphical representations for two selected values of the coefficient C. Fracture clearance, W, is taken in both charts as 0.2 in. Injection rate is on the left-hand scale, various treatment volumes are represented by the curves in the body of the chart, and fracture area is plotted at the bottom of the chart. A parallel scale gives normal sand quantities for treatments of the indicated areal extent.


TREATMENT VOLUME - THOUSANDS OF GALLONS
INJECTION RATE - BBLS PER MIN
FRACTURE AREA CHART
C = 200 X 10⁻³
FRACTURE AREA - THOUSANDS OF SQUARE FEET
TOTAL SAND - THOUSANDS OF POUNDS

the fracture clearance, W, is taken as 0.2-in. On each chart injection rate is plotted vertically with the scale at the left-hand side. Within the body of the chart is a series of lines representing various treatment volumes. The resultant fracture area in thousands of square feet is plotted at the base of the chart. Such a chart permits immediate comparison of different combinations of volume and rate, so long as the same C is maintained — so long as the same fluid and reservoir are being considered.

Determination of Sand Quantities

On each fracture area chart, there is a scale of total quantity of sand coincident with the fracture area scale. This scale is calculated on the basis of approximately 0.55 lb of sand per sq ft of 0.2-in. fracture. In other terms, this is a quantity of 4.4 lb of sand per gal of fracture volume created. This is the quantity which best available evidence shows to be optimum for the majority of wells. It is believed that, in general, the use of greater quantities of sand is not justified by the increased cost. Actually, the optimum amount of sand will vary somewhat with well depth, formation, etc. Hence, this figure should always be weighed in the light of experience.

Experience, of course, should be translated by calculation into terms of pounds of sand injected against area created. If such analysis shows the charted quantity of sand to be either too high or too low for best results, it should then be adjusted accordingly.

The charted sand quantities will result in an average sand bed thickness of approximately 0.07-in. in a 0.2-in. fracture. Thus, should it be considered feasible and desirable to inject a calculated 100 percent of fracture volume of sand, the charted values may be multiplied by a factor of 2.5 to 3.

CONTROL OF FACTORS AFFECTING AREA

Review of Development

The foregoing study enumerates the variables or factors which determine the area created by a fracture treatment. It develops an equation computing this area. It shows that this equation includes a coefficient C, which relates the dif-

ferences in reservoirs and in treatment fluids. It shows that, depending on the circumstances, C may best be defined by one of three equations. These equations are developed, and nomographic solutions are applied to them. The calculated value of C is then applied to a nomographic solution to determine fracture area. The intermediate answer of treatment efficiency is noted. Graphical charts of area as a function of selected values of C are also presented. With the fracture area thus determined, this is applied as a basis for determining an optimum quantity of sand for a particular treatment.

Controllable Variables

A consideration of all the variables will show that there are only three which are subject to control. These are the fluid to be used, expressed as C; injection rate; and treatment volume. The relative importance of these variables should be considered.

Examination of the area charts will show injection rate to be particularly important in three ranges. These are the low ranges of rate, high ranges of C, and high ranges of volume. Increasing rate from 10 to 20 bbl per min makes a very noticeable increase in fracture area. Further rate increases give progressively less additional area. When fluids are used yielding a high C value, high rates may be necessary to achieve satisfactory results. Likewise, when large volumes of fluids are contemplated, high rates contribute greatly to area created.

Increase in treatment volume is most effective with a fluid of low coefficient. Also, it is most effective in the low volume range. Each additional 5000 gal produces less additional area than the previous.

Comparison of two or more area charts reveals the importance of the factor C. Decreasing C by one unit may be equivalent to increasing volume by 10,000 or 15,000 gal, or increasing rate by 10 or 20 bbl per min. There can easily be a difference of 5 to 10-fold in fracture area, depending on the fluid used.

The change in fracturing efficiency, therefore in fracture area, with the combined variables of coefficient, volume, rate, and fracture width, is graphically illustrated in Fig. 6. The effect of any one of the variables on efficiency and on area may be calculated from the nomogram in Fig. 5.

Designing for Economy

In all calculations of treatment design, economic factors must be considered. Here is presented an excellent basis for doing this. Two possible treatments which give the same fracture area may in general be considered equally good. It is a simple matter to estimate the cost of each, and select that combination of rate, volume and fluid which does the job at least cost. By the same token, if two different treatments cost the same, but one gives twice the fracture extent, then it is twice as efficient in terms of thousands of square feet per dollar. This is the real value of the technique — engineering for efficiency and economy.

Acknowledgment

The technique presented in this report is basically an adaptation of a method developed by George C. Howard and C. R. Fast of Pan American Petroleum Corporation. This method is published in American Petroleum Institute paper No. 851-31-M, "Optimum Fluid Characteristics for Fracture Extension." This paper includes Derivation of the General Equation for Estimating the Extent of Fracture Area, by R. D. Carter. The Western Company is indebted to these authors and their colleagues for their cooperation and assistance in the preparation of this adaptation.

Giant Bit Strikes Air

AIR IS NOT THE COMMODITY oil men ordinarily prefer to find at the bottom of a hole. But in this business, anything can happen! Thus, when Terminal Drilling Company pushed a 46-in. bit 1432 ft into desert floor without striking oil or gas or too much water, the client — Phillips Petroleum Company — was well pleased!

In this case, the hole had to be a duster because it was to be a ventilation shaft to serve one of Phillips' uranium mines in the Ambrosia Lake Mining District near Grants, New Mexico. This 1432-footer and its 930-ft smaller brother, serving another Phillips mine, also may be used as emergency escape hatches.

According to Bob Woodruff, Terminal's manager of field operations, the 46-in. bit, followed by two 46-in. reamers, did a good job of straightening and reaming the hole so that casing could be run without difficulty.

Since all the mud had to come out of the shaft before the miners opened their end, Terminal made and installed special centralizers on the tubing while swabbing the hole clean. Drilling also required construction of special spider, slips, and casing clamps.

To enable the drillers to unscrew the mammoth bit and reamers from the drill stem, a mud-tight door was installed in the riser of the 48-in. conductor pipe. When the bit was pulled, a special box was inserted through the door and the bit was then lowered to rest on this box while the drillers worked on it.

The shaft was drilled in stages: 15-in. pilot holes, 26-in., 36-in. and 46-in. Two 7½ by 14-in. pumps maintained circulation through the bit. Drill pipe was 5 9/16-in. and three 8-in. by 40-ft drill collars were employed. Casing was 36-in. diameter, with wall tapered from ⅝ in. at the top to 1 in. at the bottom.

This 46-in. bit and two of the 46-in. reamers at right were used by Terminal Drilling Company to complete two ventilation shafts to uranium mines in the Ambrosia Lake District of New Mexico. Clarence Leathers, Grant Oil Tool Company chief engineer, stands between the two mammoth tools.

Multi-million dollar stakes in . . .

The Paradox Gamble—— Will It Pay Off?

The Paradox Basin continues to attract investors who have, from 1908 to 1958, put up more than $341,000,000 against difficult odds . . . some of which are still unknown

Robert L. Burch
Central Bank and Trust Company
Denver, Colorado

WITHIN THE PAST FEW YEARS, the Paradox Basin of the Four Corners region has undergone a phenomenal change in economic status. This once unwanted, submarginal land was generously awarded to the Navajo and Ute Indians for reservations where they could continue their simple living and at the same time release more "valuable" lands to their white successors. Little did anyone realize that this very region was destined to rank among the outstanding uraniferous and petroliferous discovery areas in the recent development of the Rocky Mountain region's mineral wealth.

This investigation was made to give some insight as to the total amount of capital expended by the oil industry alone in the area. These expenditures have brought forth such important discoveries as Aneth, McElmo Creek, Big Flat, and others which opened the Paradox Basin to national attention. The breakdowns presented are broad and generalizations frequent, but the expense figures which have resulted can serve as an aid in budgeting proposed expenditures and in justifying past capital outlays for individual situations.

Extracted by the author from a thesis submitted to the University of Colorado graduate school in partial fulfillment of the requirements for the degree Master of Science.

First Activity in 1891

The Paradox Basin has enjoyed a national reputation in oil circles only since 1954 or 1955, but its history is much longer and much less spectacular than most oil men realize. In studying the history of the region, it was of interest to find that the first attempt at location of oil occurred in the northern portion of the Paradox Basin in 1891, when a test well was drilled by Bamberger and Millis. This 1000-ft test was unsuccessful, but initiated the area to the oil industry and at the same time initiated the oil industry to the general pattern of disappointments which were to plague the industry for over half a century.

In the adoption of an acceptable boundary for this economic study, it was realized that an exact peripheral boundary for a major geologic basin is virtually impossible to establish in the absence of concentrated subsurface data obtained by extensive drilling and related correlation work. However, with the current limited well control in the peripheral area of the basin, the so-called Paradox evaporite sequence seemed a relatively reliable horizon and Fig. 1 shows its approximate areal extent as used for this study. In addition, the major neighboring physiographic boundaries are indicated. This northwest-southeast trending basin as outlined, covers approximately 21,000 square miles or 13,445,000 acres.

This study is divided into four time periods: 1908 to 1920; 1920 to 1940; 1940 to 1950; and 1950 to a cut-off date of January 1, 1958. Each period is treated for capital expenditures appropriate to an overall picture of the economic status of the Paradox Basin.

1908 TO 1920

Record keeping in all phases of oil exploration and development was poor during the early 1900's, but from the available figures, a reasonable picture of the drilling activity has been assembled for this period. A sum of only 33 tests were drilled to 500 ft or deeper, and 21 of these reached Pennsylvanian sediments. The total footage drilled was only 36,124 or an average of 1100 ft. Using a somewhat tenuous, but reasonable estimate of $18 per ft for total drilling cost estimates, a total capital outlay of only $660,000 would be expected.

During this period of development, exploration and leasing costs were virtually non-existant, by modern standards, and are not considered in this study.

Strike at Mexican Hat

In 1908, E. L. Goodridge made the singular discovery of oil in the basin at the old Mexican Hat field. This brought considerable interest to the area, but the best available data indicates total cumulative production at only about 50,000 bbl of Pennsylvanian crude, all of which was consumed locally.

Summarizing, the oil industry's capital expenditures for the period from initial discovery to 1920 can be estimated as:

Exploration Cost — Negligible
Leasing Cost — Negligible
Drilling Cost — $660,000
Marketing Cost — Negligible

1920 TO 1940

This intermediate period of development was singularly disappointing for the oil industry. Numerous surface features were known from published government mapping projects, and the anticlinal theory of oil accumulation was being proved in other Rocky Mountain areas, but no oil discoveries blessed the Paradox Basin during this 20-year interval.

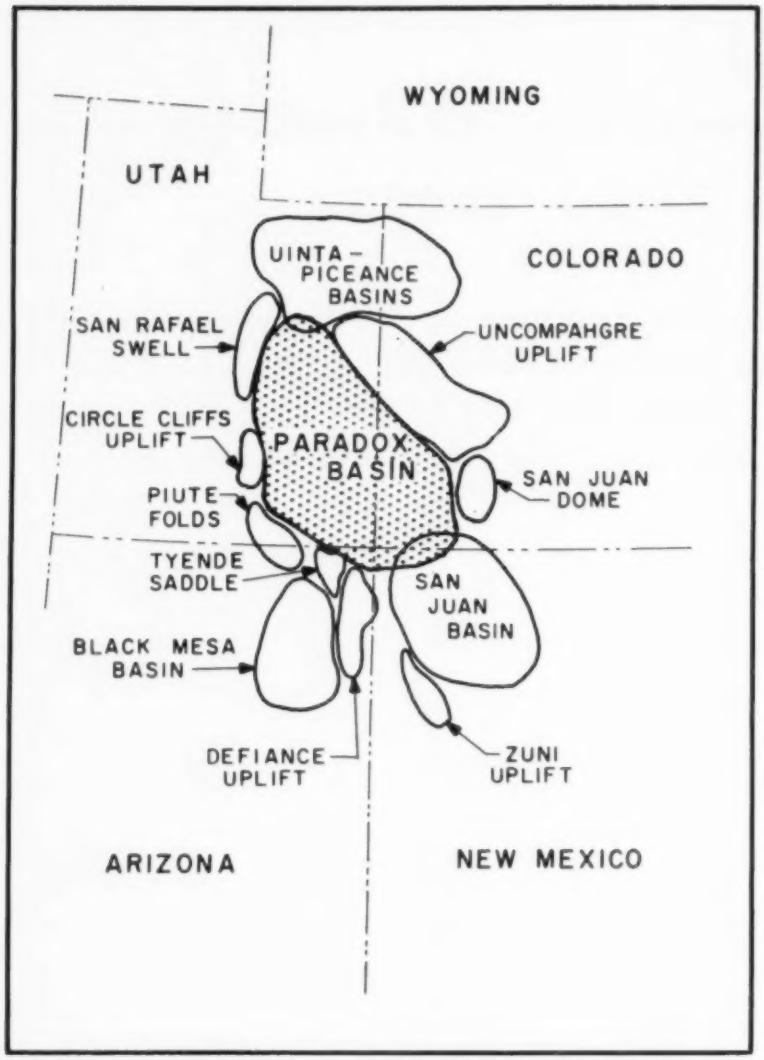


FIG. 1. Extent of the Paradox Basin for the purpose of this study was taken to correspond to the so-called Paradox evaporite sequence. Map also shows neighboring physiographic boundaries.

20 Years — 75 Wells

Surface mapping was conducted on a minor scale, and for cost purposes, an estimate of $500 in exploration expenses for each wildcat test drilled to better than 500 ft throughout the basin was used. Similarly, an arbitrary $1000 total leasing expense figure per test was used. The drilling history for this period indicates only 75 test wells for a total of some 203,950 ft of dry hole. Thus it is apparent that expenses were beginning to climb as the average depth increased to 2720. Of the 75 tests, only 49 penetrated Pennsylvanian sediments and nine of these tested Mississippian and deeper strata. Again, using the $18 per ft, total drilling expenses for the 20 years would amount to $3,750,000.

Summarizing, the oil industry's capital expenditures for the period from 1920 to 1940 can be broken down into these estimates:

Exploration Costs — $37,500
Leasing Costs — $75,000
Drilling Costs — $3,750,000

Therefore, the approximate total expense to the oil industry for this period was $3,863,000 which was offset by no production or proved reserves of oil or gas.

1940 TO 1950

This decade marked the beginning of the modern development of the oil potential of the Paradox Basin. Exploration practices developed and proved in other areas were introduced. In addition to expanding surface parties, the seismograph, gravity and magnetometer surveys began operation along the more readily accessible roads and trails. These highly complex operations added considerable expense to the industry.

To arrive at cost estimates, some assumptions were of necessity made. For surface work figures, a conservative estimate of 130 crew-months for the 10 years was made based upon the number of major operators who drilled at least two Pennsylvanian tests each, and a field season of six months per year. With monthly expenses of from $1500 to $1800, an industry surface work expense figure of approximately $220,000 was arrived at. From scouting records, it was further determined that a total of 47.8 seismograph crew-months were logged in the Paradox Basin as outlined for this study over the 10-year period. At a low $20,000 per crew-month, this would amount to $956,000. Similarly, 43.5 crew months of gravity-meter work and 18.2 crew-months of magnetometer mapping were recorded, and at $3750 and $3000 per crew-month respectively, additional expenses of about $165,000 and $55,000 resulted.

Rotary Drill Introduced

The drilling history was altered by the introduction of the rotary drill, and for this 10-year period 74 wildcat tests were drilled to an average of 4400 ft. Of these, 47 tested Pennsylvanian strata, and 10 went on to test Mississippian and deeper potential horizons. The total footage drilled was 325,854 ft of which almost 2600 ft were core samples. In addition, 65 drillstem tests were attempted.

In explanation of drilling costs from 1940 to the present, the following method presented the most reasonable and generally justifiable cost per well. Each test was considered separately and compared, based on the number of days on location, coring and testing, total depth, wildcat or pool designation, etc., with known costs for nearby tests. In all, the actual costs to the respective operators were known for 39 wildcat tests throughout the Paradox Basin and 31 development wells in the Aneth and McElmo fields. Actual costs vary with different operators, but it was believed that this gave a more accurate cost figure than accepting "industry average cost figures" for Four Corners wildcat and pool drilling costs.

Using the procedure outlined for the 74 tests drilled to 500 ft or deeper, the total estimated expense of drilling for the period was $7,965,000 or about $24.50 per ft — a reasonable figure in view of the coring, testing, and lack of available repair and supply requirements.

Leasing expenses remained minor

in view of the absence of significant discoveries, and estimating $1600 expense per location (3200 acres at $0.50 per acre), total expenses to the industry amounted to a little over $120,000 for this period.

By 1950 the well-density figure had been increased to one test for each 115 square miles, and the past 10 years had brought forth many encouraging shows and greatly increased the knowledge of the basin's geology. Due primarily to these encouraging signs, many major companies became interested in the area and the trend was set for greater exploration.

Expressed in tabular form, the industry expenses for the 1940 to 1950 interval are:

Exploration Cost		Leasing	
Seismic	$956,000	Cost	
Surface	220,000	Total	$120,000
Gravity	165,000		
Magnetic	55,000	Drilling	
		Cost	
Total	$1,396,000	Total	$7,965,000

Therefore, the approximate total capital expense to the oil industry for this decade was $9,500,000 with only encouraging signs and a few marginal type discoveries to show for the time and expenses incurred.

1950 TO 1958

The preceding data from 1908 to 1950 were incorporated into this study to illustrate that the recent successes in the Paradox Basin were not without many years of expensive dry holes and bitter disappointments. In a similar manner, they tend to emphasize the very rapid expansion of interest by the oil industry for the area in comparison with the capital expenditures poured into the basin in the past eight years.

To make more clear the study of expenses for this period, it is convenient to break the costs into the following generalized headings: Geology, Drilling, Leasing, Marketing, and Miscellaneous Cost Data. It should be borne in mind that where factual information was available to the author it was used. Where estimates were of necessity used, a definite effort was made to keep them conservative and all such estimates were discussed with several men actively working within the area of investigation before incorporation into this research.

Geology

The previous decade pointed the way toward large capital expenditures in all phases of exploration geology. Accompanying the major oil companies to the area were the most advanced technological procedures for prospecting. However, modernization did not push out the old standby, surface geology. Outcrop studies became even more important as it became apparent that the key to Pennsylvanian accumulations of oil and gas was as much stratigraphic in nature as structural.

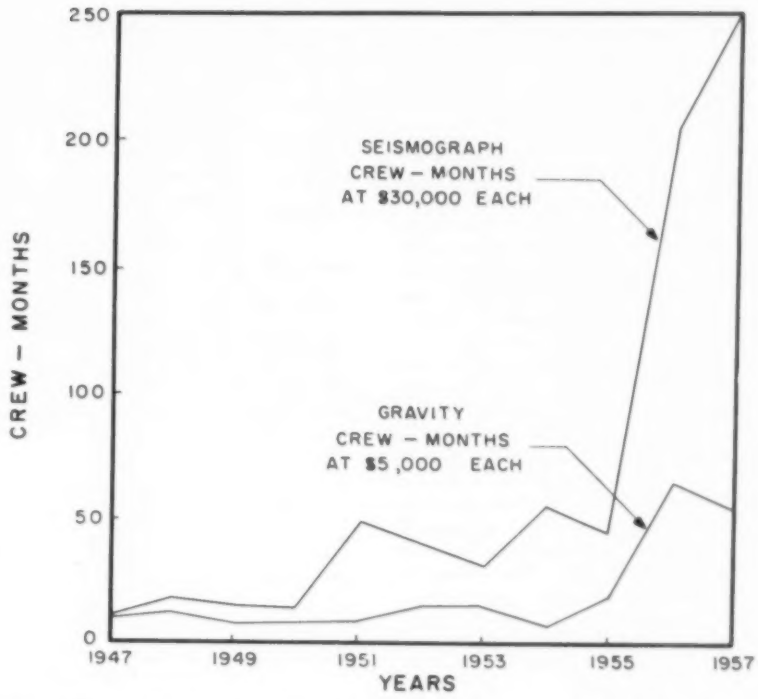


FIG. 2. Seismograph and gravity activity in the Paradox Basin from 1947 through 1957.

The mobility of surface parties makes it difficult to estimate crew-months of activity, but it was assumed that the typical major company working the Paradox Basin kept two parties out each six-month mapping season. From an average of 12 major operators working from offices established during this eight years in Durango, Colorado, alone, over 1150 crew-months of surface work were accumulated. With total expenses running close to $2000 per crew-month in this area, this phase of exploration cost would amount to approximately $2,304,000. This figure does not include the additional crew-months of parties operating from home offices in Farmington, Salt Lake, Denver, and other areas outside the basin proper, and is thus very conservative.

Photogeology. Introduced during the 1950's as an exploration tool by most of the active operators in the Paradox Basin was photogeology mapping. This method of mapping is the study and evaluation of aerial photographs to obtain structural information over wide or inaccessible areas in a relatively short period of time. It is particularly adaptable to the angular topography and excellent exposures typical of the area. Properly utilized and with occasional ground checks, photo mapping can be used early in an exploration program to determine areas for more detailed study.

Photo mapping is typically contracted or occasionally done by photo sections in the larger companies, and the total cost is figured at about $6 per square mile of coverage. One photo consultant conservatively estimated that the industry coverage within the 21,000 square mile basin would amount to 120,000 square miles. This effective but inexpensive phase of exploration would thus account for only about $720,000 of capital expense to the industry.

Beginning in the late 1940's, the number of seismograph parties operating within the Paradox Basin increased sporadically. From the Oil Scouts' Association data, the crew-months varied from 17.3 in 1948 to 14.1 in 1950 to a high of 251.4 in 1957. In all, a total of 692 seismic crew-months were logged for the eight years under consideration. From the same source, 189 crew-months of gravity work were indicated.

One of the major operators in the area estimates costs for seismic and gravity parties in the area as $30,000 and $5000 per crew-month respectively. At these rates the industry spent $20,760,000 for seismic work and $946,000 for gravity surveys. During the peak of activity in 1957, the industry was spending $625,000 per

month for seismic information alone. Fig. 2 is the graphic presentation of both seismic and gravity activity for the eight-year interval.

Analysis of data. Increased drilling activity brought forth a wealth of subsurface information for analysis by all who were actively interested in the Four Corners area. Any estimate of time and personnel so engaged would be highly tenuous, but a conservative estimate would be two geologists from the typical company working full time on stratigraphic or structural correlations. Again using the average of 12 Durango offices only, there would have been some 24 men at about $550 per month working on subsurface studies. Over the eight-year period, their salaries alone would amount to $1,267,000.

Thus you see that in simply geology and its related studies, the oil industry in only eight years has spent approximately $26,000,000. This in itself is enough to arouse serious consideration, but is relatively small compared to other phases of capital expenditures in the area.

Drilling

Considerable time and effort went into the accumulation of a complete drilling history for the Paradox Basin as outlined for this study. With the excellent cooperation of the Scouting Department of the Western Division of The Carter Oil Company, a list of some 730 tests over 500 ft deep drilled from 1908 to 1958 was made.

As previously explained, the estimated cost figure for each test from 1940 to 1958 was arrived at by comparing the individual situations for each test as carried on the scouting data with known total costs for nearby tests. It would be impossible to reproduce the complete drilling history tabulations, but Table 1 presents the total picture of the Paradox Basin drilling since the Mexican Hat discovery in 1908 up to 1958.

Although Table 1 is self explanatory, since almost 87 percent of the total cost was concentrated from 1950 to 1958, a further breakdown is necessary. Two basic classifications were used for more detailed study. Wildcat or exploration tests and pool or development wells were grouped and there were 303 and 245 respectively. In wildcat footage, the cost per foot varied from a low of $24.20 per ft in 1956 to $67.50 per ft in 1952. This last figure indicates how misleading an averaging procedure can be.

$1,500,000 Duster. In 1952 only eight wildcat tests were drilled, but one deep one cost the operator over $1,500,000 before the location was abandoned. This should tend to remind the operator of a proposed drilling program that no test of a true wildcat nature can be considered "average" until it is satisfactorily completed. The wildcat density figure dropped from only one test per 114 square miles in 1950 to one in 44.5 square miles by the close of 1957. For actual Pennsylvanian wildcat tests since 1940 for the 21,000 square mile basin, the figure is only one for each 69 square miles. This figure is an excellent indication of the vast area as yet unproved within the Paradox Basin by the modern drill bit.

A total of 23 discoveries of varying importance were logged in the 1950 to 1958 period. They ranged from marginal shallow gas discoveries in southwestern Colorado to the significant Shell Oil Desert Creek discovery in 1954 which triggered major activity. The really convincing test was The Texas Company No 1-C Navajo Aneth discovery which was completed in February 1956, for an initial potential of 1704 bbl of 43-gravity oil per day from

TABLE 1. Paradox Basin Drilling History Summary — 1908 to 1958.

	Total tests	Shallow tests	Pennsylvanian tests	Mississippian or deeper tests	Total footage	Coring footage	Drill stem tests	Estimated cost	Cost per foot
1908 to 1920	33	12	21	0	36,124	0	0	$ 660,000	$18.30
1920 to 1940	75	26	40	9	203,943	0	0	3,750,000	18.50
	108	38	61	9	240,067	0	0	4,410,000	
1940 to 1950	74	17	47	10	325,854	2,535*	65	7,965,000	24.40
	182	55	108	19	565,921	2,535	65	12,375,000	
1950 to 1958	548	62	386	100	3,076,503	75,061**	1193	80,054,000	26.00
Industry Total	730	117	494	119	3,642,424	77,596***	1258	$92,429,000	$25.40

*Number of Cores: 228
**Number of Cores: 2,423
***Total 2,651

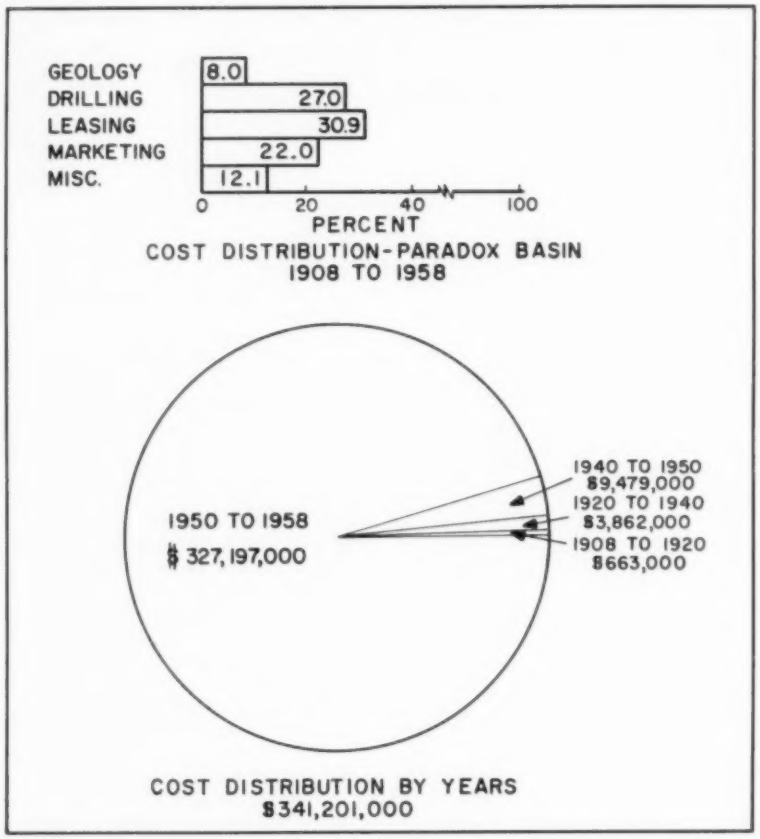


FIG. 3. Distribution of investments in the Paradox Basin. Costs during period from 1950 to 1958 represent approximately 96 percent of total expenditures made by the industry.

Pennsylvanian strata — a significant discovery in any area.

Also important was the 1957 Pure Oil Mississippian discovery at Big Flat which gives multiple pay prospects to a former "one shot" area. From 1956 on, discoveries in the southeastern corner of Utah became the rule rather than the exception and justification for the long unrewarded confidence in the area began to be realized.

Average cost per ft. The 245 development wells, primarily in the Aneth area, cost an estimated $34,091,000 against $45,963,000 for the 303 wildcat tests. On an eight-year basis, the typical wildcat total cost per foot was approximately $27.50 to total depth and for development wells completed to the storage tanks, approximately $24.30 per ft. These figures can be used as guides for prospective pool or wildcat drilling programs in the Paradox Basin.

Combining the expenses of the 548 tests drilled from 1950 to 1958, it is startling to see that a total capital expenditure figure for the oil industry for drilling expenses alone would amount to slightly over $80,000,000. This figure underlines the confidence placed in the as yet unknown ultimate potential of the Paradox Basin in recent years.

Leasing

The 13,445,000 acres of land as outlined for this study are currently estimated to be about 90 percent under lease or option. Within the four-state area the following approximate land breakdown was used, based on available land status maps: 9,545,000 acres of federal land; 1,350,000 acres of fee land; 875,000 acres of state property; and 1,675,000 acres of Indian lands. To check specifically each type of acreage, leasing terms, etc., would be beyond the scope of this research, but the following estimates are based on data from several interviews with men who have dealt with land problems in the basin for years.

Indian lands bonus. Bonus payments to the various Indian tribes are on record and, including up through only the first of four multi-million dollar sealed-bid Navajo sales in late 1957, in the Colorado and Utah portions of the basin over $53,760,000 in bonuses have been paid on Indian lands alone. It is further estimated that an additional $1,000,000 has been paid on Arizona and New Mexico Indian lands within the basin as outlined. Bids on these sales range from a few dollars per acre to the all-time high for the area of $4308 per acre.

The high bonus payments are directly attributable to the very encouraging discoveries and the unknown potential of the area. Individual bids vary widely, and the complete cooperation of exploration, production, and land sections is essential to obtain a figure which is justifiable and yet still has a chance of being high bid. These high bonus payments have naturally restricted most of the activity in southeastern Utah to the major operators.

The remaining acreage in the Paradox Basin presents a more difficult problem when attempting to arrive at a total bonus payment. Wide variations are to be expected, but during the past few years a typical leasing price for both federal and state acreage would be $5 per acre and from $2 to $6 per acre for fee property. Using these figures, bonus payments above the Indian receipts would amount to about $48,025,000 for federal and state and $2,152,000 for fee properties. Therefore, a reasonable total leasing expenditure for the oil industry from 1950 to 1958 would be approximately $105,000,000.

Robert L. Burch *was born and educated in Colorado, graduating from the Colorado School of Mines in 1952 with the degree of geological engineer. Upon graduation, he went to work with the Murphy Corporation, doing geological work in Montana. His association with this company was interrupted for 20 months when he served with the U. S. Army Engineers as survey platoon leader in the Philippine Islands.*

In September, 1956, he returned to the University of Colorado to begin graduate work in business management and finance. He chose the Paradox Basin for an industry cost study as the subject of his thesis for the Master of Science degree. Upon completion of his graduate studies, he accepted a position with The Central Bank and Trust Company of Denver, Colorado, in the Oil and Gas Department.

Marketing

Disposition of crude oil from the Paradox Basin was not a problem for the first 46 years of its development. However, with the major discoveries in the Aneth area, the problem became acute. No operator likes to shut in production for lack of a market, with the resulting delay on the return of his capital. In the Four Corners area, it was obvious that the local market could absorb but a fraction of the potential uncovered, and early marketing attempts by long and costly trucking and rail transportation to distant refineries were excessively expensive and wholly inadequate.

Pipelines biggest cost. The industry had three choices: West to California refineries; southeast to the Gulf facilities; or a local refining build-up. After much calculating and market analysis, plans for two major pipelines from the area were announced. The Four Corners pipeline was to be a 16-in., 675-mile, ultimate capacity 160,000 bbl-per-day line to Los Angeles at an estimated capital outlay of $50,000,000. Shortly afterward, The Texas Company outlined a 16-in., 515-mile, ultimate capacity 84,000 bbl-per-day line to tie in with lines to the Gulf Coast at an estimated capital cost of $25,000,000.

This combined total of $75,000,000 represents the largest unit expenses incurred by the oil industry in the exploration and exploitation of the Paradox Basin. It also indicates the confidence of major interest holders in the basin of its potential. The announcements of a ready market for crude also had a marked effect upon expansion of exploration and development plans throughout the basin.

Miscellaneous Cost Data

The four major categories discussed thus far are those most familiar to the typical operator. However, this is not the whole story. There are many "hidden costs" which can be very significant to an overall study, and also to companies operating or planning operations in any area of interest.

State survey. For example, in the early 1950's Shell Oil Company had several areas in southeastern Utah which they felt held considerable promise after extensive seismic work. However, the area was largely unsurveyed and Shell, as principal contributor, advanced some $200,000 to the Bureau of Land Management in Utah to have the area surveyed. This was to avoid costly litigation over lease ownership of valuable acreage in future Indian sales.

Field trips. Another example of hidden expenses in the development of an area is in geological field trips. Although relatively inexpensive — only about $30,000 for the Paradox Basin proper — they play a very important part in the dissemination of information on surface and subsurface studies. To disregard this expense would make little difference to the overall picture, but field trips are valuable aids to any exploration program where an interplay of information and ideas may lead to important discoveries.

Overhead. Overhead is an ever present cost to the oil industry regardless of the size of an operator or the area

TABLE 2. 1908 - 1958 Expenditures.

	Geology 8.0%	Drilling 27.0%	Leasing 30.9%	Marketing 22.0%	Miscellaneous 12.1%	Totals 100%
1908–1920	Negligible	$ 660,000	$ 3,000	Negligible	Negligible	$ 663,000
1920–1940	$ 37,000	3,750,000	75,000	Negligible	Negligible	3,862,000
1940–1950	1,394,000	7,965,000	120,000	Negligible	Negligible	9,479,000
1950–1958	25,997,000	80,054,000	104,937,000	$75,000,000	$41,209,000	327,197,000
1908–1958	$27,428,000	$92,429,000	$105,135,000	$75,000,000	$41,209,000	$341,201,000

(See Fig. 3 for graphic presentation of overall data.)

being worked. It would be a monumental task to get an accurate breakdown of office space, housing projects, distribution of employee time to various geologic studies, and the distribution of management effort to the phases of planning, budgeting, and co-ordinating activities for the Paradox Basin. It is especially true of this area because of its remote location and national importance such that offices throughout the Western States are devoting time and money to its study. However, by borrowing from a national study made in 1952 by H. L. Struth, it was found that the overhead figure for exploration and development in the oil industry was 5.6 percent of the total capital expenditures. As this figure represents the average of a very large sample, it should prove satisfactory for estimating overhead costs based upon the capital expenses outlined thus far.

The total capital expenditures for the oil industry from 1950 to 1958 amount to approximately $286,218,000. With this base for calculation, the imputed overhead expenses chargeable to the Paradox Basin development for the same period amounted to $16,979,000.

Capital. The capital expenditures for the eight-year period thus total a staggering $303,197,000. But this sum of money must be bought and paid for just like all other supplies for operations. The assumption commonly made by oil operators is that future production will be adequate to pay off debts, provide a reasonable return on the original investments, and provide risk capital for further ventures. However, until such production becomes a reality, the cost of capital is a relentless problem.

The cumulative production through 1957 for some 12 producing oil fields in the Paradox Basin was just over 2,250,000 bbl of crude and would be of little assistance in paying off the $303,000,000 thus far invested. Therefore, the final "hidden cost" to the oil industry would be the cost of capital to finance a $300,000,000 venture. Assuming that the major portion of this total came during 1955, 1956, and 1957 for simplicity, it will follow that the debt was approximately $100,000,000 for each of the three years. Further, assuming an absolute minimum effective cost of capital in the money markets to substantial oil companies during this period to be 4 percent annually, the imputed charges were approximately $4,000,000 in 1955, $8,000,000 in 1956, and $12,000,000 in 1957.

The cost of capital will continue until marketing facilities provide the income to pay off the original investments, but those companies not fortunate enough to discover and own producing properties within the Paradox Basin must look to some other source of income to offset previous expenses.

Thus we see that the total capital expense to the oil industry for the eight years of intensified search for oil in the basin from 1950 to 1958 was over $327,000,000. In retrospect, this amazing figure is broken down roughly into these categories and percentages: Geology and related phases, 7.9 percent; drilling, 24.4 percent; leasing, 32.2 percent; marketing, 22.9 percent; and miscellaneous, overhead, and cost of capital, 12.6 percent.

CONCLUSIONS

This economic analysis was undertaken to determine just how much capital has been required to bring about the discoveries which have placed the Paradox Basin in the enviable position it currently enjoys in oil circles. Table 2 shows the 1908 to 1958 expenditures.

These $341,200,000 odd dollars have brought forth as yet unknown ultimate reserves, but it is sufficient to point out that the operators of the two 16-in. pipelines to distant markets from the Paradox Basin oil fields have invested $75,000,000 in direct anticipation of extensive production. However, it has not been the success of any one exploration tool or production technique, but rather the combined efforts of all phases of the oil industry's prospecting and development operations which have hung on through many lean years to achieve the current successes.

The next 5 to 10 years should see continued efforts throughout the Paradox Basin bring forth additional reserves and pipeline production to more than justify the huge gamble with Mother Nature in the quest for wealth from the elusive "black gold." ★ ★ ★

Western Hemisphere Logging Anniversary

THE NUMBER 216 LaROSA is one of many wells that pump oil on the Bolivar Coast of Lake Maracaibo in Venezuela. The well stands as a mute salute to an idea that helped revolutionize the oil finding industry. For Schlumberger ran the first electric log in the Western Hemisphere on LaRosa No. 216.

The initial survey was made for the Shell Company on March 6, 1929. It consisted of a single resistivity curve made by plotting the readings every meter in the hole. Schlumberger Surenco, S.A. took cognizance of the milestone recently with a series of celebrations culminating with the unveiling of a bronze plaque at the well site which reads, "On March 6, 1929, on The Shell Company's Well R-216, Schlumberger ran the first electric log on the American Continent."

Among those participating in the occasion were Robert D. Ford, Schlumberger Surenco president; Maurice Schlumberger, member of The Schlumberger Limited Board and brother of the company founders; Dr. Eloy Anzola, board member of Schlumberger Surenco.

An old friend came to see LaRosa No. 216 and take part in the ceremonies. He is Jacinto José Briceño, the Venezuelan employee with the longest service with Schlumberger Surenco. Señor Briceño was a Shell helper on the rig that drilled LaRosa No. 216 and was present when that first log was run 30 years ago. He joined Schlumberger Surenco a few months after the well was completed.

The log was run on the Venezuelan well about six months before a log was accomplished in the United States.

Maurice Schlumberger, left, brother of the Schlumberger Well Surveying Corporation founders, chats with Señor Jacinto José Briceño at ceremonies marking the 30th anniversary of the first electric log in the Western Hemisphere.

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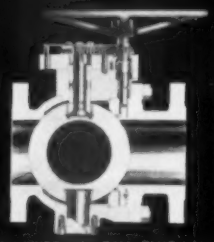
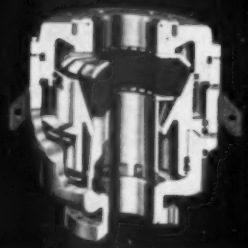


HYDRIL TYPE "K" BALL PLUG VALVE



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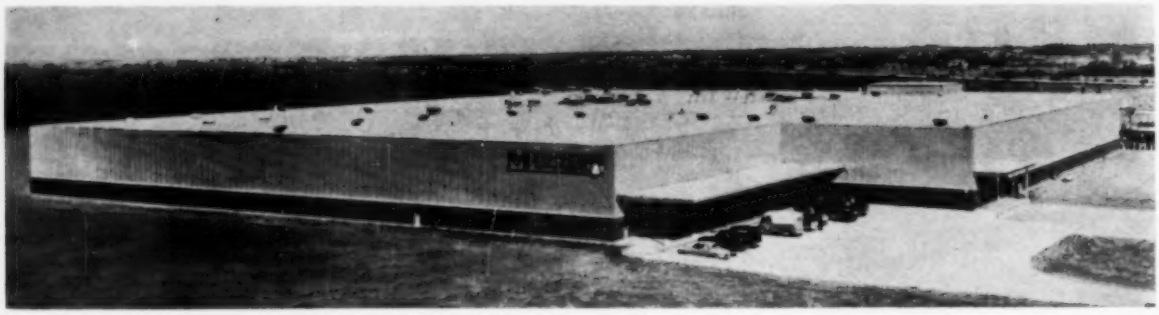

Mission Manufacturing Company's new facilities, recently completed, in Houston's Industrial District off the Hempstead Highway. There are 167,000 sq ft under one roof. Aluminum siding serves dual purpose of being eye-pleasing and resistant to corrosion.

New Plant 'Automates' Pump Parts Production

AN ALL-NEW pump parts manufacturing plant has been formally opened by Mission Manufacturing Company in Houston, Texas. Located on 72 acres in the Houston industrial district, the plant—comprising 167,000 sq ft under one roof—is producing more oilfield fluid end parts for reciprocating pumps than any other manufacturer in the world, says W. B. Sharp Jr., board chairman of Mission.

The 35-year-old company also is a major manufacturer of numerous types of valves, and produces a variety of drilling tools. The newest product is the Hammerdril, a pneumatic tool designed for mining operations that is being widely accepted.

The company's new plant comprises 167,000 sq ft under one roof — nearly four air conditioned acres — housing 300 production units and processing 35,000 lb of metal a day.

Production Line

A "straight through" production line enables a product to move in a straight line from the raw materials area to the warehouse. This system simplified dividing the plant into production departments, and as a result, one supervisor can be responsible for all phases of processing one or more products from the raw materials stage to finish.

He can closely supervise heat treating, machining, inspection, assembly and painting. Another supervisor takes over after final inspection for warehousing and shipping.

An example of the efficiency of the production line is in this fact: In the old plant, one product moved 5000 ft in the total manufacturing operation. In the new plant, this same product travels only 900 ft before it is ready for shipment.

Automation

Automation is accomplished in spite of the necessity for production in "job shop lots." For example, the plant can produce a huge number of piston rods, but in the total monthly production are hundreds of different sizes. All machine tools, or combinations of machine tools, can be converted easily to change types of output.

Just put into operation is a machining unit which will be used to rough turn liners. One hundred horsepower is directed to the spindle of this tool and it can remove 25 lb of metal in one minute.

An outstanding example of design ingenuity in the new plant is in a machining complex for the production of piston rods. This is known as the Numerical Control Rod Production Unit. The setup is composed of three integrated machines whereby the "programs" for the machine tools are electronically introduced by IBM cards. In other words, the machining done by the units is dictated by coded data on the cards.

With this numerical control procedure, the machining program can be changed in three minutes, compared to almost two hours in manual control installations.

Founded in 1925

Mission was organized 35 years ago as the Mission Sales Company by oil country pioneers W. B. Sharp Sr., W. T. Campbell Sr., and Ed Prather. Sharp built the first oil refinery in Texas and is also remembered for his development with Howard Hughes of the rotary rock bit. Campbell was an original incorporator of The Texas Company, and Ed Prather, a financier who died only recently in his nineties, was active in many plays of the Spindletop era.

The original company represented a single product line, the old Kibele Piston, manufactured by Mission Tool and Supply Company of San Antonio.

The great majority of the company's top officials have a long record of service with Mission. The company president, Richard White, joined Mission in 1938 as a junior engineer.

Officers

The present officers of Mission Manufacturing Company are: W. B. Sharp, chairman; Dudley C. Sharp Sr., vice chairman; Richard White, president; Charles Bartley, vice president of engineering and manufacturing; and Anan Golub, vice president, secretary and treasurer. These officers with Dudley C. Sharp Jr., W. T. Campbell and Ross P. Bennett make up the board of directors.

Future Plans

Mission President White has announced that plans already are under way for the construction of an office building adjacent to the manufacturing facility. At present, administrative offices are temporarily situated in a portion of the warehouse area.

The Company Abroad

In addition to the Houston headquarters facilities, Mission last year put into operation a manufacturing plant in Northern Ireland.

Export offices are maintained in New York and London. Sales facilities also are situated at various points in South America. ★ ★ ★

Among the new jobs performed by nitrogen is . . .

Use of Nitrogen in Drillstem Testing

This inert gas, used as a control blanket in drillstem testing, provides uncontaminated samples, surface control of pressures, positive protection of drillstem

A. W. Smith
Cook Testing Company
Odessa, Texas

COMPRESSED NITROGEN was first introduced to the oil industry as a service item some four years ago in California. Originally its primary use was to minimize plugging action and sticking of anchor in drillstem testing in unconsolidated and soft formations. Since the initial introduction, many new uses have been developed for nitrogen, and it has become one of the major products in the petroleum industry.

Nitrogen is a valuable aid in drillstem testing, whether or not the well depth is such that protection is required for the drillstem from excessive hydrostatic mud pressure. When the well depth and mud weight are such that the drillstem near the bottom of the hole is not in danger of collapse, it is practical to pressure the entire drill string from the surface with nitrogen before the packer is set or the bottom-hole testing valve is opened. This automatically tests the surface equipment for leaks with nitrogen before the tool is opened.

When the packer is set and the tool is opened, the nitrogen pressure in the drill string prevents a sudden release of pressure to atmospheric at the face of the formation. This tends to reduce sloughing of the formation, and aids in obtaining a packer seat by avoiding a sudden differential across the packer equivalent to the hydrostatic mud pressure.

Test Procedure

The surface valve is not opened until several minutes after the bottom-hole testing valve is opened. This permits the engineer in charge to determine if the formation pressure is greater than the nitrogen pressure, and to observe the length of time required to obtain the maximum surface pressure. A surface pressure gage and indicator (Fig. 1) provide a permanent record of the surface pressures. The indicator is also equipped with a combustible gas indicator to sound a warning bell when formation gas first reaches the surface.

The nitrogen may be slowly bled off as desired. This gradually increases the differential pressure across the packer rather than subjecting it to a sudden pressure shock, thus avoiding many packer failures. This same procedure has been effective in minimizing difficulty caused by plugging action of lost circulation material when large amounts of this material are present in the drilling fluid.

In a recent test (pressure chart shown in Fig. 4) this procedure collected 110 ft of lost circulation material, cut 60 percent oil, in the pipe. The gentle lifting of the blanket permitted this recovery. The shock of opening the test tool would almost certainly have plugged the tester without the back pressure provided by the nitrogen.

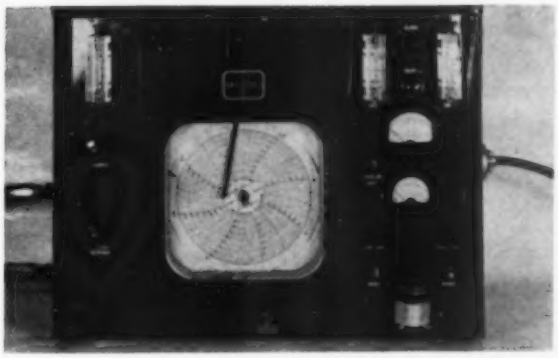

FIG. 1. **Indicator and recorder** make a constant record of surface pressure while the drill string is being filled with nitrogen and throughout the flowing period of the well.

The use of a nitrogen blanket has, in effect, changed the flow bean of the test from the bottom of the hole to the surface of the well where it can be controlled by the engineer in charge. The nitrogen blanket process has definitely been proved to permit successful tests in areas where it previously has been impossible to get a test due to the characteristics of the formation.

Nitrogen Control Valve

When the well depth and mud density are such that protection from collapse is needed over the bottom portion of the drill string, a nitrogen blanket may be run by using a nitrogen control valve. (Fig. 2 and 3). This valve is a recent innovation used in conjunction with nitrogen in drillstem testing. It is a special tool which permits pressuring any desired length of the bottom portion of the drill string to any pressure necessary for protection from collapse or for formation control.

The valve is installed in a special shear pin sub and can be run at any depth in the string. The shear pin feature of the sub provides a method for removal of the valve should it become necessary to run tools inside the drill pipe below the sub while it is in the hole. To remove the valve, it is only necessary to pump fluid into the drill pipe from the surface. Rig pump pressure is sufficient to shear the pins holding the valve in the sub. After the pins are sheared, the valve may be pumped to bottom, leaving full drill pipe diameter through the sub. This is a valuable safety

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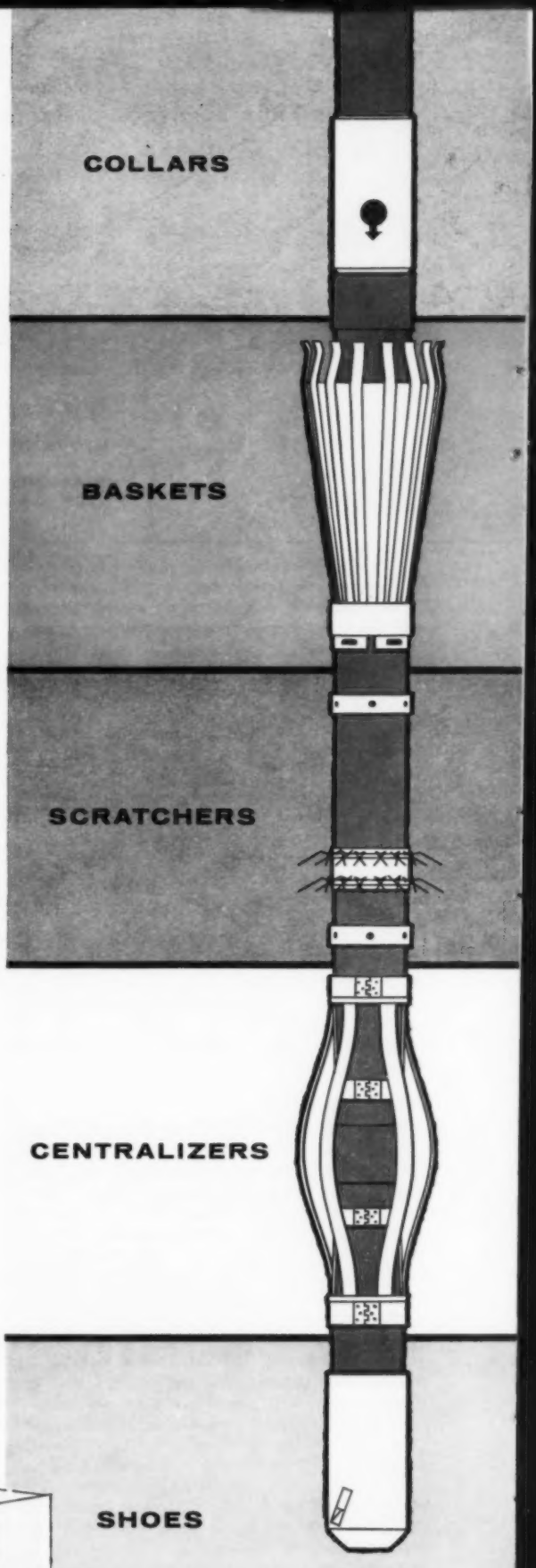

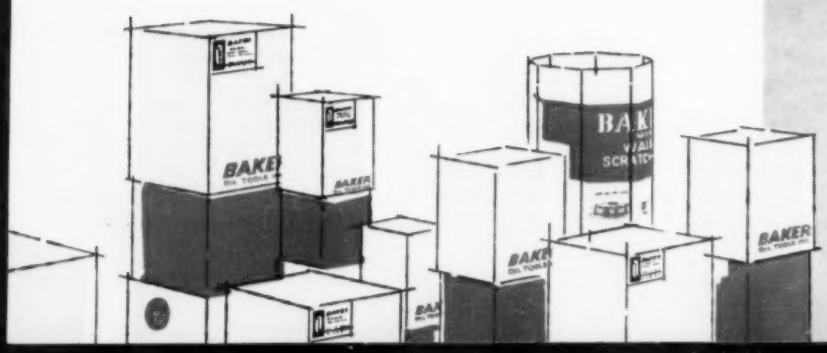

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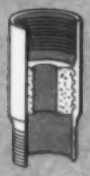

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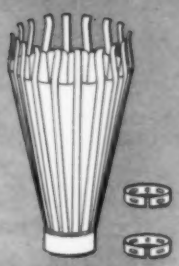

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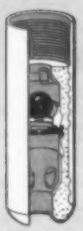
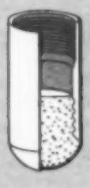


Flexiflow Fill-Up Shoe Product No. 160

Cement Float Shoe Product No. 100

Cement Wash-Down Whirler Float Shoe Product No. 120



Cement Bull Plug Shoe Product No. 103

Cement Guide Shoe Product No. 102

Triplex Cementing Shoe Product No. 1363

feature to permit running free point indicators, stringshots, etc., inside the pipe should the pipe become stuck during testing operations.

Valve Operation

The operation of the valve is similar to that of a gas-charged gas lift valve. If, for example, the equivalent of 2000 ft of water is required to protect the drill pipe from collapse, the valve is pre-set at the surface with nitrogen to the pressure equivalent to 2000 ft of water. (Approximately 460 psi). The valve is installed in the hanger sub and the sub is installed in the drill string after the test tool and 2000 ft of drill pipe have been run in the hole.

The sub has a side port valve below the control valve for entry of nitrogen. A high-pressure hose is connected to the entry port from a nitrogen transport truck. Nitrogen is delivered from the truck to the drill pipe until the control valve opens and pops nitrogen to the atmosphere. (The time required to fill 4000 ft of drill pipe consumes only approximately 12 minutes of rig time. This is much less time than would be required to fill the same length of drill pipe with water.) The drill string is then run to the bottom of the well as in any other drillstem test.

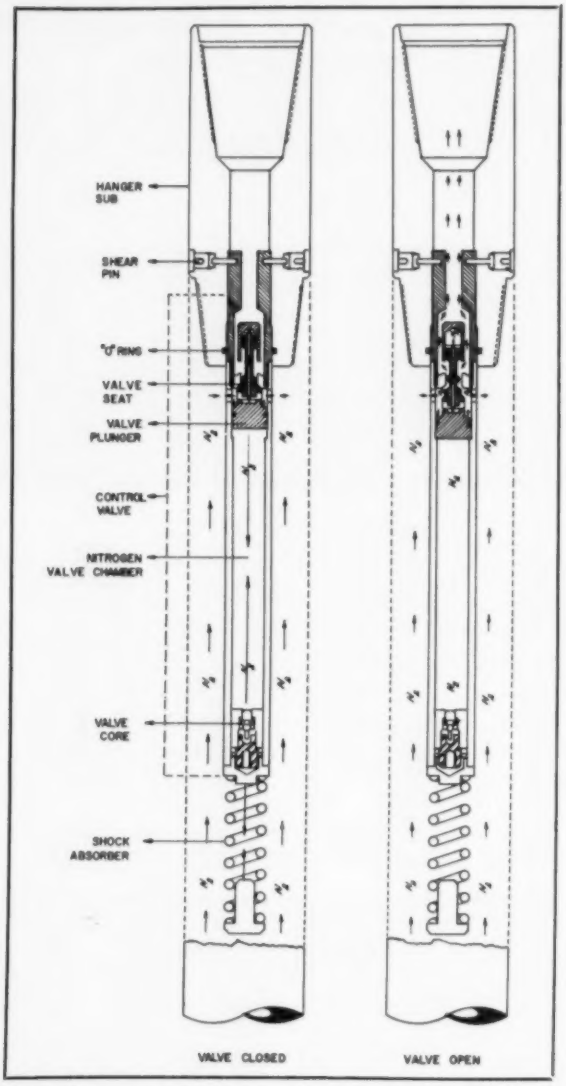


FIG. 2. **Nitrogen control valve,** shown at left in closed position, is preset to control the nitrogen pressure used to prevent collapse of the drill pipe. Valve opens, as shown at right, when flowing formation pressure is 10 to 20 psi greater than the preset nitrogen back pressure.

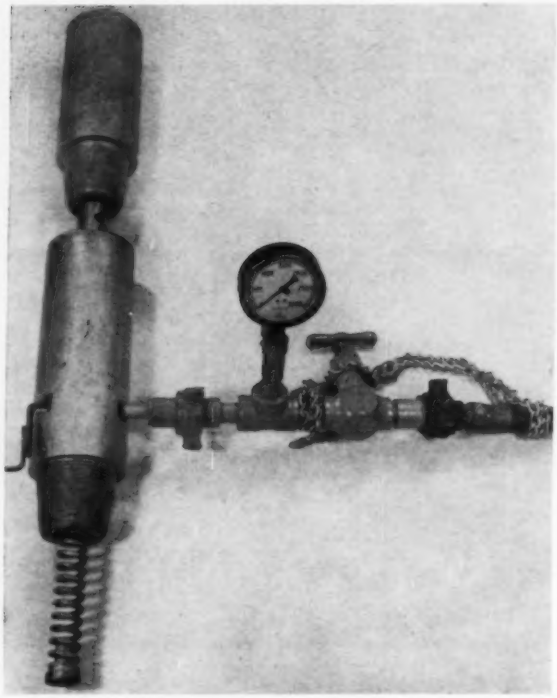


FIG. 3. **Hanger sub with nitrogen valve** in place is in position to be screwed into the nitrogen filler sub. Supply line is shown connected to the nitrogen entry port in the filler sub.

After reaching bottom, the initial shut-in pressure may be taken if desired. When the tool is to be opened for the test, the drill string is rotated at the surface the required number of rounds to open the testing tool. This exposes the formation pressure to the nitrogen charged portion of the drill pipe. If the flowing formation pressure is 10 to 20 psi greater than the nitrogen back pressure, the nitrogen control valve will automatically open, giving the indication at the surface that something is entering the drill string from below the packer.

If the formation is tight and so low in permeability that it does not give up enough formation fluid to increase the pressure in the nitrogen chamber sufficiently to open the control valve, the nitrogen will be compressed enough to permit recovery of enough uncontaminated formation fluid to analyze. (Pressure chart shown in Fig. 5.) This, along

Arthur W. Smith *has been directly associated with the oil industry in various phases for the past 23 years. For 15 years he worked in the production and drilling businesses in Louisiana and Texas. He has devoted the last eight years to drillstem testing and has served as general manager of Cook Testing Company's Permian Basin area since January, 1956.*

The first Cook nitrogen plant was completed in Odessa, Texas, in April, 1957. Added to his duties as general manager of the testing operation was the responsibility of introducing nitrogen to the petroleum industry in this area. He is the inventor of the nitrogen control valve.

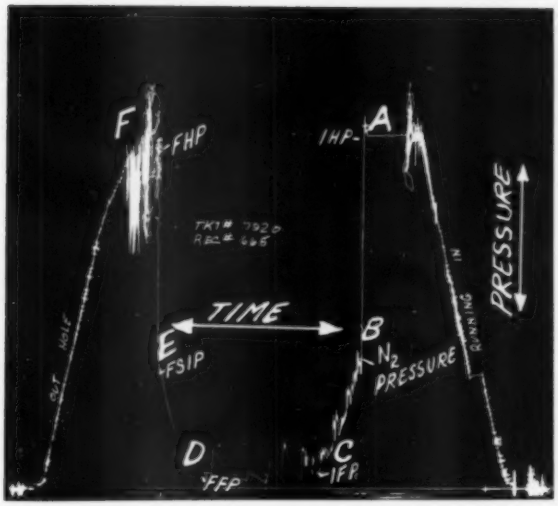


FIG. 4. **Actual chart of successful test,** following a plugged tool from lost circulation material. Step-by-step procedure was as follows: **A.** Initial mud pressure in hole. Pressuring up entire string of pipe before opening tester. **B.** Back pressure from surface with nitrogen. **B to C.** Bleeding off nitrogen on small choke at the surface. **C to D.** Tester open to atmospheric pressure with no back pressure. **D to E.** 30-min final shut-in pressure. **F.** Final mud pressure out of hole. Recovered 110 ft of lost circulation material in pipe, cut 60 percent oil.

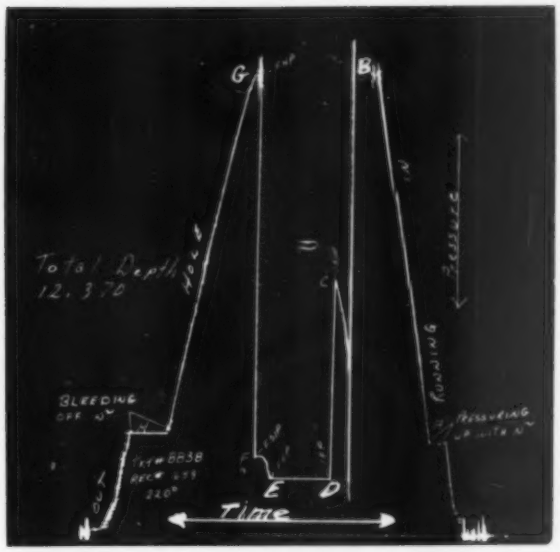


FIG. 5. **Actual pressure chart** with nitrogen back pressure greater than formation flowing pressure. **A.** Pressuring up on 2400 ft of pipe using the control valve. **B.** Initial hydrostatic mud pressure. **C.** Initial shut-in pressure. **D.** Initial flow pressure. **E.** Final flow pressure. **F.** Final shut-in pressure. **G.** Final hydrostatic mud pressure. **H.** Bleeding off nitrogen at surface. Recovered 130 ft gas-cut mud. Control valve preset with 450 psi, with 400 psi nitrogen on pipe for protection.

with the pressure recorder readings, leaves no doubt as to the nature of the formation fluid.

The nitrogen cushion is of particular value if the fluid recovered in such instances is water. When a water cushion is used it is often impossible to detect a small recovery of formation water. The use of a nitrogen cushion completely overcomes this difficulty. When nitrogen is used, there is no question as to whether water obtained on the test came from the formation or not, and no question as to the quantity of water produced. There is no dilution of produced water by cushion water. Oil is recovered in one body rather than being scattered through a long column of cushion water. (Pressure chart shown in Fig 6.)

If the zone tested is a high-pressure gas zone, the nitrogen control valve automatically retains the pre-set back pressure on the portion of the drill pipe it is desired to protect from collapse. When a water cushion is used on a high-pressure gas test, the water cushion is sprayed out at the surface, leaving the pipe empty and subject to collapse when the testing tool is closed and the pressure is bled off at the surface.

Drill String Protection

Nitrogen is more versatile than water. Any portion of the drill string may be protected with any pressure desired. Suppose 1000 ft of drill collars are used on bottom and 1000 ft of drill pipe above the collars require protection. With water, a minimum of 2000 ft would be required, which would exert a pressure of 860 psi on the formation when the tool is opened. With nitrogen, only 430 psi would be required to protect the 1000 ft of drill pipe. Furthermore, the nitrogen gives the full 1000 ft of drill pipe the benefit of 430 psi protection.

The protection given by water varies from 430 psi at the bottom of the drill pipe to zero psi at the top of the 1000 ft protected, and gives the greatest protection, from 430 to 860 psi, in the drill collars where it is not needed at all! This versatility would be of particular value should a low-pressure zone be tested with considerably strong pipe, such as drill collars, on bottom, with a weaker section of pipe higher up in the string.

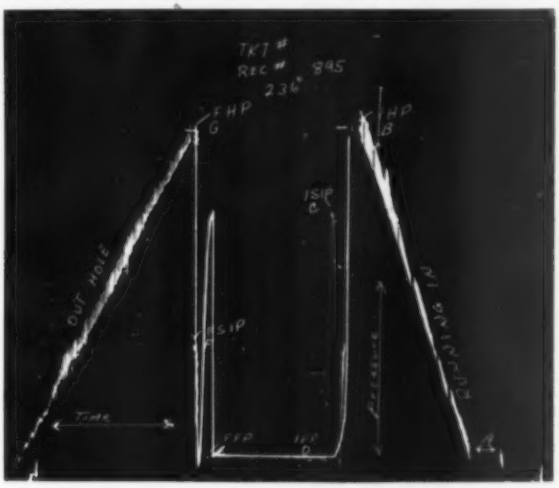
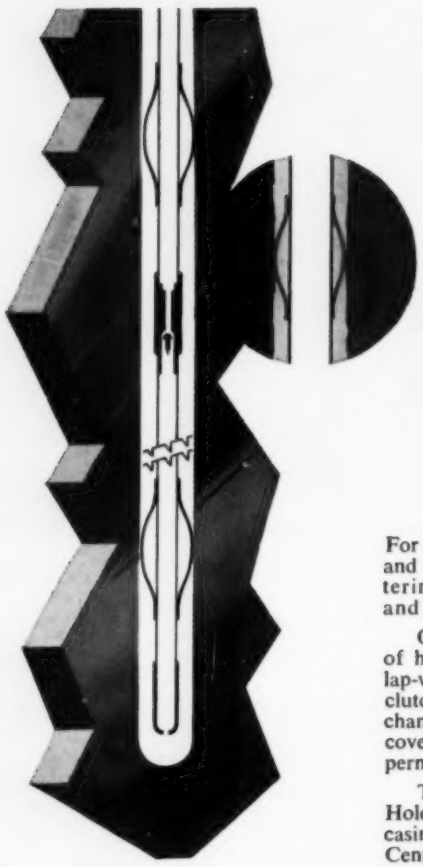


FIG. 6. **Pressure chart** of test using 1000 ft of water cushion for pipe protection. **A.** Time required to put water cushion in pipe. **B.** Initial hydrostatic mud pressure. **C.** 15-min initial shut-in. **D to E.** Tool open. **E to F.** 15-min final shut-in. **G.** Final hydrostatic mud pressure. Total depth — 12,560 ft. Recovered 50 ft of free oil, 60 ft of oil-and-gas-cut drilling mud, 40 ft of water-blanket-cut mud, and 1010 ft of oil-and-gas-cut water blanket.

Other Uses of N_2

Now that nitrogen is available in the oil fields as a service item, many other practical uses have been found for it. It has been used to displace fluids in wells loaded with water. It has been used to displace fluid from the annulus at the surface of gas injection wells for safety reasons. Nitrogen is also used to purge propane, butane, and gas lines before repair.

Nitrogen under pressure can detect leaks in surface equipment at relatively low pressures. It is being considered as a tracer in waterflooding operations and plays a part in a new process designed to shut-off water in gas or air drilled wells. ★ ★ ★



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There is a Halliburton Casing Centralizer designed for every well..."Slim-Hole" Centralizers are tailored for specific slim holes drilled or for liners run inside casing; available in 3½" O.D. liner through 9⅝" O.D. casing sizes..."Tubing" Centralizers help protect tubing and collars against wear when string is pulled and re-run; also for wells where tubing is used as production string or in water injection wells for maximum centering and better placement of cement; available in 2" EUE through 3½" EUE sizes.

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  ...surpasses many non-weld limiting devices and stop collars in capacity load to limit movement of centralizers on casing without welding—not illustrated.

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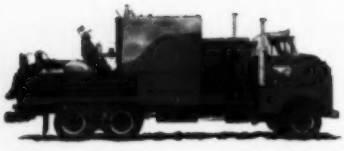

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284 SERVICE CENTERS – JUST MINUTES AWAY FROM YOUR WELL

Tubing Power Tongs

Rugged automatic tubing tools becoming standard well servicing equipment — affording uniform make-up, faster jobs, safer operation

Paul Teague, Jr.
Wichita Supply Company
Wichita Falls, Texas

FIELD ACCEPTANCE OF POWER TUBING TONGS in the past five years has been something slightly less than phenomenal. Operators are demanding them for uniform tubing makeup; well servicing contractors are finding the hydraulic or air-powered tools are closely correlated with smoother, faster and safer operations. Depending on well servicing depth, power tongs can make-up and break-out tubing 2 to 10 times faster than using manually operated tongs, snipes or "Crumbies."

The power tools are accepted as an integral part of well servicing units on the West Coast and are becoming standard equipment in much of West Texas and New Mexico — and even the most shallow operating areas are noting significant moves in that direction.

Although major acceptance by the well servicing contractors and operators has been seen in the last five years, the power tubing tong was introduced more than 25 years ago. The first known power tubing tool, known as the tubing spinner, was introduced by Hill & Foster Company, Inc., in 1932. The unit was actuated by an electric motor, which transmitted power to a four-jawed rotating head through a Model-T Ford transmission. The jaw arrangement is similar to that employed in a tool offered today by the company's successor. Although tested and approved by a major oil company, the project was "pigeon-holed" for lack of demand and surplus of manpower that year.

A practical power tubing tong was introduced to the industry by Hillman-Kelley in 1939. It was well received by the oil industry, which had long recognized the necessity for a tool that would make-up and break-out tubular joints rapidly, uniformly, and less hazardously than through the use of the spinning rope and/or conventional tong. Large scale production of the power tools, however, did not come until after World War II.

The merit of using power tubing tongs is now recognized to such an extent by some major companies that they will not allow any other method of tubing make-up to be used on their leases. The uniform make-up insured by the use of the power tong has since contributed greatly to the elimination of leaky joints, reduced frequency of pulling jobs, and increased life of tubing strings. The servicing contractor, on the other hand, has found that in addition to running pipe faster, greater crew safety and reduced crew fatigue, lack of coupling damage due to hammering and improper make-up has resulted in keeping customers.

Although advantages of power tongs in make-up and break-out of tubing are common to all power tubing tongs now on the market, beyond that, much of the similarity between individual tools ends.

Principal power tongs in field use today may be classified, for sake of description, in three styles, each representing different, but equally sound, engineering approaches to the

construction of power tubing make-up and break-out tools. Each tool will herein be discussed by basic differences in the rotating ring construction surrounding the pipe-gripping jaws. One manufacturer's tool is built on a slot rotor principle; the second is constructed with a split rotor; the third maker's tong employs a full-circle rotor. All three tools have easily-replaceable tong dies to handle tubing from approximately 1.05-in. to 4.5-in. OD. All three have two speed transmissions — a low gear for breaking out, and high gear for spinning and make-up. All three manufacturers furnish tongs with either air or hydraulic power.

The Slot Rotor Type Tong

This tong, made by a West Coast manufacturer, employs a reverse chain drive in a fully-enclosed sealed oil bath transmission. The chain drives the slotted rotating ring surrounding a cam-and-roller gripping mechanism. Three or four full-length dies are engaged on the pipe. The interchangeable jaws and bushings are changed quickly by removing two pins.

The slot in the rotor is aligned with the outside safety opening by an automatic positioning mechanism.

The jaw and bushing automatically engage the pipe and operation is controlled by a single valve.

Operation of the slot-rotor type tong is reversed by a unique "roll-over" suspension arm, convenient for testing joints or changing couplings. For long periods of operation, the tong may be used with motor side up by turning jaw and bushing up-side-down and transferring to the opposite side of the inner ring. The adjustable "roll-over" arms also double as a balancing mechanism for the wire line hung tong.

An air or hydraulic pressure gage, depending on the tong power source, calibrated in foot-pounds of torque provides the indicator for proper make-up. The torque indicator, coupled to a pressure release valve, assures the operator of uniform make-up in every joint. The tong, with jaw bushing, weighs about 535 lb (air) or 588 lb (hydraulic).

Split-Rotor Type Tong

The split-rotor power tong draws power from a gear-type hydraulic or air motor. Power is sent to split rotating ring and gripping jaw through a two-speed, gear-driven transmission and clutch. Tong is actuated by a "unitized" hydraulic motor and throttle valve. Clutch and gear shift are located on both sides of the tong to permit ease of operation from any direction.

Jaw pins are "snapped" out by pressing two stainless steel buttons, eliminating need for changing tools. Quick jaw changeover is accomplished by pulling the pins, taking out the jaw and inserting the new size. Built-in stops on the jaws permit proper fit on tubing without tong adjustment. The tool has a positive self adjusting automatic reverse.

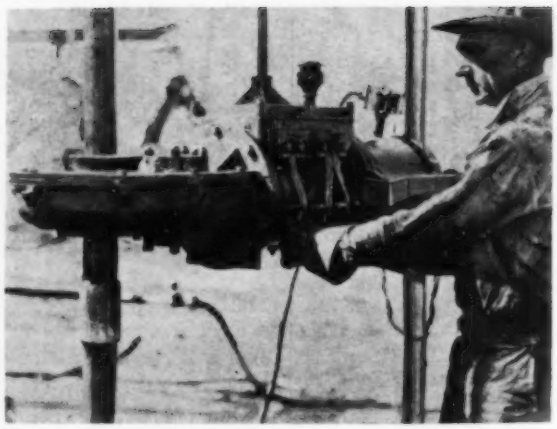

FIG. 1. **Early tubing spinner,** introduced in 1932, was electric powered. The unit came complete with back-up post, safety gong, 40 ft of electric cable for $950.

A rigid, adjustable roll-over arm with position lock allows rapid roll over for breaking out tubing. The hanger arm level stays in adjustment on both axes.

The split-rotor tong, when swung onto tubing, is constructed so that jaws grip automatically and safety door on the tong case closes. On reaching the proper amount of torque, the tong is automatically disengaged from the pipe. This West Coast manufacturer's tong, air powered, weighs 450 lb; hydraulic powered, 525 lb.

Full-Circle Rotor Tong

Because of the complete "doughnut" type construction of the full-circle rotor type, this tong is not removed from the tubing between joints. It remains on the pipe and is raised and lowered after making-up or breaking-out each joint. Two levers control the operation of the tong, one for forward and reverse, the other for high and low speeds. The speed lever is shifted to high speed, approximately 100 rpm, then as the speed begins to decrease, the lever is immediately shifted to low gear — without stopping — through a double multiple disc friction clutch. When the lever is released to center position, the tool stops rotating.

Power is transferred from the hydraulic or air motor to a full chain drive. As power is applied, the ring gear moves in the tong's five equally spaced jaws, centers the

FIG. 2. **Jaw assembly** of slot rotor type tong.

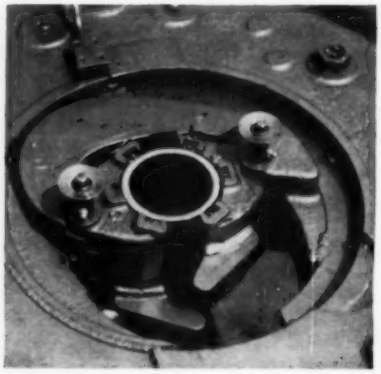

FIG. 3. **Split rotor** tong's jaws are removed by two buttons.

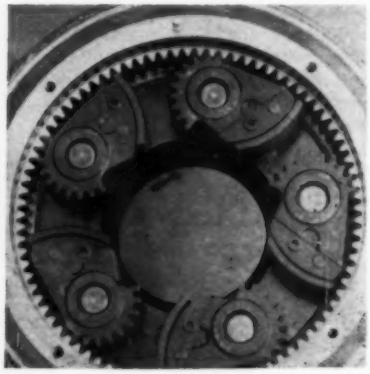

FIG. 4. **Jaws** are equally spaced in full circle type tong.

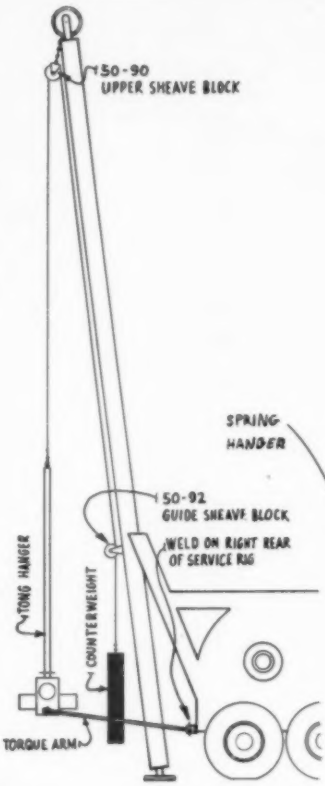

FIG. 5. **Counterbalance** eases raising and lowering of full-circle rotor tong.

FIG. 6. **Rigid line** with spring hanger supports split rotor and slot rotor tongs.

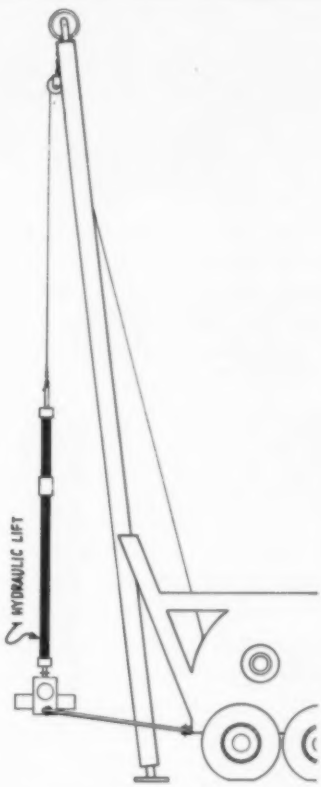

FIG. 7. **Hydraulic lift** is available as optional equipment for full-circle rotor tong.

pipe, and exerts even pressure around it. Jaws are turned over for break-out operation.

Torque is measured by a gage, mounted on top of the tong, and mechanically connected to a rigid torque arm — the tension read directly in foot-pounds, regardless of hydraulic pressure. Weight of the full-circle rotor type tong, air driven, is 810 lb; hydraulic driven, 756 lb.

Air vs Hydraulic Power

All manufacturers of power tubing tongs offer the tools with either air or hydraulic power. Both systems have advantages.

The air driven tong is probably slightly better for the threaded joint as it is more flexible in its operation. The air tong tends to cushion or slow down when an irregularity or foreign matter, such as dirt or sand, is in the threads. In the case of the hydraulic tong, it forces its way through without any slow down which can gall or burn a thread instead of easing through and working out the irregularity as does the pneumatically driven tong. Most air tongs deliver about 5 hp, continuously, through rotary or reciprocating type air motor.

On the other hand, the air driven tong is only about 20 percent as efficient and requires a heavier prime mover, and the air compressor required is much larger and heavier than the hydraulic pump required. Air equipment, however, is noted for its long life and smooth operation, but torque control is less positive and the cost of equipment is greater. Most air difficulties arise from the fact that inadequate compressor capacities are too often used.

The hydraulic powered tongs, developing about 12 hp continuously, are silent in operation. Since the hydraulic drive is 5 times more efficient than air, engine maintenance and fuel consumption is lower. Most hydraulic tongs are faster, with a maximum speed rating from 90 to 100 rpm.

The final decision as to the choice of air or hydraulic tools may be made on the basis of existing power units available on the rig. The hydraulic power source may be driven by the hoist or drawworks engine. If the derrick is hydraulically raised or extended, the same hydraulic system may often be employed. In some instances, the rig may have adequate air compressor systems, which are used in air starters and clutches on the controls and engines on the rig.

Power Tong Operation

Just how *fast* is power tong operation? Minimum time to break-out tubing joints with a power tong is about 7 seconds; minimum make-up time is about 5 seconds. Actually, the speed of running tubing with power tongs is restricted only by the ability of the crew to handle the pipe. A good driller and his crew can run three complete jobs in one day at shallow depths, or the automatic tool may be responsible for saving as much as five hours on one job in pulling 13,000 ft of 2½-in. tubing.

At what depths do power tongs become economical and

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For many wells, the most promising treatment still is acidizing. In some of these wells, however, acidizing has not been successful because of emulsions, silicate swelling or similar problems.

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Thousands of treatments in hundreds of different fields have given Dowell unmatched experience in selecting the right addition agents and in tailoring treatments to give the operator the best return for his money.

In designing special acid treatments, your Dowell engineer has outstanding qualifications. First, he is backed by the organization that created inhibited acidizing for the oil field. Then, he is personally familiar with the formations and problems in your area.

Important extra benefits, however, come from the research facilities of Dowell and The Dow Chemical Company. When a particularly tough problem arises, Dowell scientists in the Tulsa Research Center are ready to help you. This is additional assurance of success in treating "problem" wells.

To meet the more common conditions, Dowell offers dozens of *proved* addition agents that can be combined to make literally thousands of different treatments. The box below gives just a few examples of how Dowell addition agents are used to improve acidizing results.

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If you want to treat Eocene or Miocene sands—

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If your formation is very tight—

—you can usually reduce injection pressures and speed up the return of spent acid by adding a Dowell surface tension reducing agent. These agents are designed to minimize surface tension of either spent or unspent acid. Dowell surface tension reducing agents often reduce injection pressures by hundreds of pounds per square inch. As to return of spent acid, some wells must be given a remedial treatment before the well will produce if acid is used without a surface tension reducing agent.

Addition Agents Make Your Wells Worth More

If you want to acidize a slow-reacting dolomite—

—consider the use of a Dowell intensifying agent to speed the reaction. Wells treated with intensified acid often bring production increases that far outweigh the small added cost. Many wells also hold up better when intensified acid is used.

If your formation is extremely permeable—

—you may want to use the new F.L.A.® (Fluid Loss Additive) for acid or water, recently developed by Dowell. This agent actually reduces fluid loss rate to about 25 ml in 30 minutes. This low rate is designed to give deeper penetration, a larger drainage area and thus more profitable treatments.

If you want to make certain—

—rely on your Dowell engineer for help. His knowledge of local field conditions, combined with Dowell's records of successful treatments, are added assurance of the proper treatment for *your* particular well.

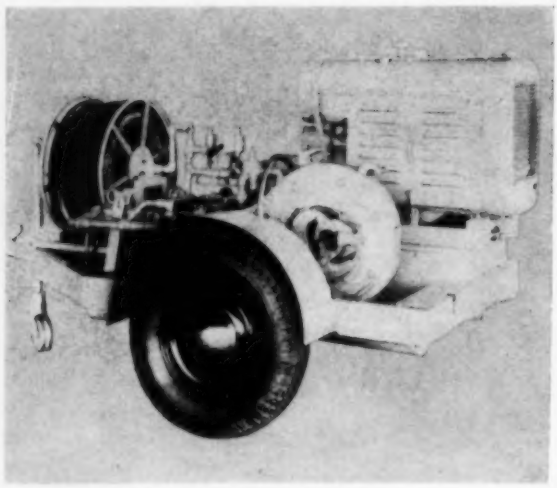

FIG. 8. **Trailer-mounted power unit** is current favorite among contractors for portability.

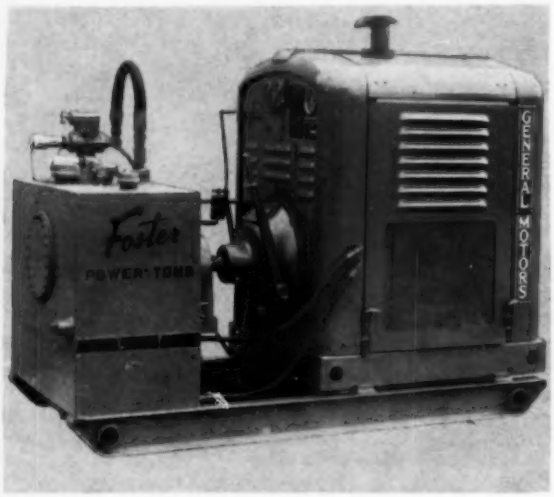

FIG. 9. **Skid-mounted unit** is offered for many who leave tong on rig, but prefer separate power.

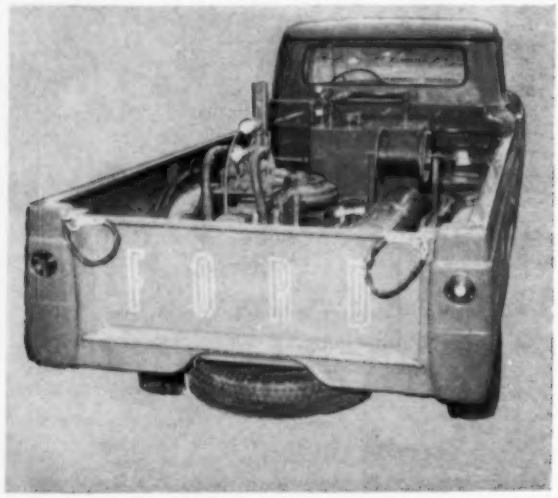

FIG. 10. **Truck-mounted unit** is choice of tong operators who use truck engine as source of power.

profitable? Although little time can be saved on a well much less than a thousand feet in depth, considering rig up time, the safety and proper, uniform tubing make-up factor remains — at any depth. Skill is not a factor in effective power tong operation — if the crew is effective in manual tong operation.

All power tongs are operated by one man, although different controls and procedure is followed for different-make tools.

The split-rotor tong is operated with the tong suspended from a rigid line. Vertical travel of the tong is necessary because of the thread travel of the tubing. This is compensated for by the use of an enclosed spring between the tong and the line on which it is hanging. Swinging the open tong against the tubing locks the jaws and closes the safety guard automatically. Tubing is rotated by applying power through the throttle valve to motor. Pressing the throttle control valve forward automatically reverses the motor and aligns the throat in the rotor and the opening in the case for removal of the tong from the pipe.

The slot-rotor type tong is also suspended from a permanently anchored cable and the distance from the floor remains the same. With the elevators attached to a joint of tubing the tubing is lowered to a suitable stub height and slips are applied. When the next joint of tubing is stabbed, the power tong is swung onto the pipe. A single valve controls the operation. When the joint of pipe is made up, a button on top of the tong is pressed to back the head up to position allowing it to be removed from the string of tubing. The entire tong is then swung clear and hooked ready for the next joint.

The full-circle rotor tong, since it is not necessary that it be removed from the tubing between joints, is raised and lowered with each joint. The tong is lowered close to the floor as the elevators lower the string into the hole. Slips are applied, another joint of tubing is stabbed, and the tong is raised above the collar and ready for use. The speed lever is shifted into high speed, used to make up the tubing. (Low gear is used primarily for tubing break-out.) Rotating the tool closes the jaws around the pipe. When the speed lever is released to center position, the tool stops rotating. To release the jaws from the pipe, the reverse lever is engaged and all five jaws swing back clear of the pipe. The tong is then lowered close to the floor in original position. Since this tool must be raised and lowered frequently, a sheave is mounted on the mast to hang a counterbalance to permit ease of handling.

Rigging and Rig-up Time

Rig-up time for power tong operation ranges from 10 to 30 minutes, determined largely by the type of power source mounting and mast rigging required. If the power tong is an integral part of the rig, and all rigging allowed to remain in place on the mast, rig-up time, obviously, is at a bare minimum. If sheaves, counterbalances, and/or tong lines must be rigged at each installation and power unit "jockeyed" into position near the rig, as may be the case if power tongs are used only occasionally, considerable more time will be required.

There are four ways that units can be mounted for use. One, the engine and pump or compressor is mounted on a trailer with sufficient room for the tong itself. This is the most popular method since this type of equipment is extremely portable.

Power units may also be mounted on a truck, with the engine of the truck as the source of power, and mounting the tong and its accessories in the bed of the truck for transporting.

Third, the whole power unit can be skid mounted; and fourth, the present or added hydraulic system on the rig

FIG. 11. **Roll-over assembly,** used on slot rotor type tong, speeds tubing break-out.

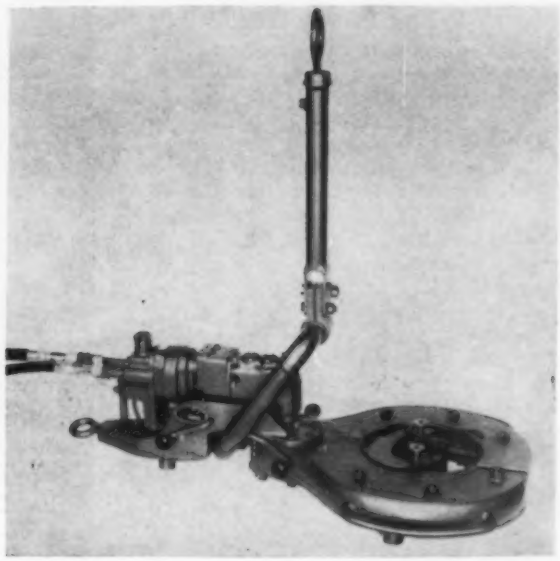

FIG. 12. **Adjustable, locking** roll-over arm is feature of split rotor type tong.

itself is usually sufficient to operate hydraulic power tongs. This has one disadvantage, however, in that each rig must be equipped with a hydraulic system. For example, if a contractor owns five rigs and wished to purchase only one power tong without a power unit, then all five rigs must be equipped with a hydraulic system.

Independent power units should be removed at least 25 ft from the rig, and should be equipped with as much as 50 ft of hose.

To save time, the contractor should — whether he owns or rents power tongs, either for any or all his units, provide permanent suspension systems for the equipment. A permanently anchored wire line is sufficient for the split-rotor and slot-rotor type tongs. Horizontal safety tong lines should be permanently fixed to the unit or derrick leg. Possible reverse torque on these tools could be eliminated by two cables at right angles to the tong, or by using a rigid arm.

The full-circle rotor type tong necessitates some form of counterbalancing. This is accomplished easily with a double drum, masted rig with extra crown block sheaves. Some contractors leave the cable and a special sheave permanently mounted to the mast. Several types of tong suspension systems are illustrated.

One tong manufacturer offers, as optional equipment, a powered hydraulic cylinder that is attached to a permanently anchored line on the mast. A lever positioned on the tubing tong operates a two-position valve which in turn actuates the cylinder. To raise the tool a slight lift on the lever does the trick. The hydraulic cylinder also has a built-in air cushion to allow the tool to travel with the pipe as the threads make up.

An important phase of the tong rigging-up operation is the tong leveling, vital to proper tubing make-up and elimination of any possibility of tong dog "bite" on the joints. Some tongs compensate for leveling within the tong hanger. One tong has a cross test level mounted on top to aid in the initial set up to prevent misalignment between jaws and the pipe.

Make-up Torque

With the development of power tongs came the torque gage. The question immediately arose in the industry: "What is the proper torque for proper make-up?" As a result of this recurring question the American Petroleum Institute's Standardization Committee on Tubular Goods (1948) led by Charles Dunlop of Humble Oil & Refining Company, asked the committee on RP 5C1, headed by Carl Dawson of Standard Oil Company of California, to appoint a task group to study the problem and to make recommendations.

It was decided that the problem would be approached from three different angles: (1) A questionnaire was sent out to the leading oil companies on a high engineering level to insure a professional approach. (2) Observations were made on actual runs in the field where power tongs were being employed to determine what torques were being used and the degree of make-up. (3) A test was evolved which could be made in the field in an attempt to determine what the optimum make-up should be with respect to torques, position and any other factors.

It should be understood that no specifications on the proper make-up of oil well tubing have ever been submitted either by the manufacturers, the users or the American Petroleum Institute.

It is generally recognized that three turns beyond the ring or plug gage point, which is known as the hand-tight standoff, is considered proper. It is sometimes erroneously thought that if the face of the collar is made up flush with the vanishing point of the thread (last scratch) the make-up is proper. This is true only if the coupling and the pin are exactly to the nominal API dimensions. However, as the tolerance allowed on both the coupling and the pin amount to plus or minus one turn, the pin can stand out two threads or be burried two threads and still be within the API tolerance and be a perfect joint. This means that if the joint was to be made up with the coupling face flush with the last scratch, it is possible that the joint could be either two turns tight or two turns loose, and inasmuch as there is only three power turns involved, it would be either 33⅓ percent made up, or over-made up 66⅔ percent.

Tests that were run by the RP 5C1 task group with the cooperation of many of the oil companies in Texas, California, and Wyoming were based on the torque required to make three power turns. With this data, a tentative set of values and a recommended procedure involving recom-

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prevents drill collars from falling during washover operations

When you call Homco for a fishing or cutting job you know you are getting the most skilled help in the oil fields. Thirty one years experience in the field enables Homco to offer you an unequalled service. Trained and experienced operators use the Homco designed tools that get the job done fast.

As an example, in many instances drill collars are lodged some distance from the bottom of the hole and when washed over they fall to the bottom, necessitating an extra trip into the hole to retrieve them. And, in many cases the collars lodge on the bottom requiring additional washover operations.

The Homco Drill Collar Spear is designed to prevent this. This tool has the spear attached to the wash pipe through shear pins allowing the spear to be screwed into the joint connection of the collar. After the connection is made the pins are easily sheared, allowing washover to begin. The spear is in the catch position as the collars are washed over preventing the collars from falling. A free point indicator may be operated through this tool at any time.

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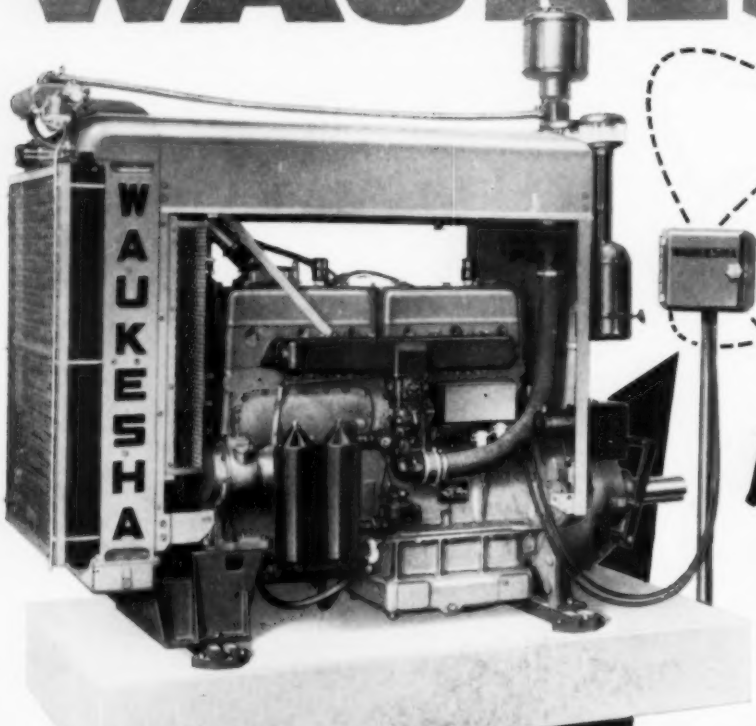
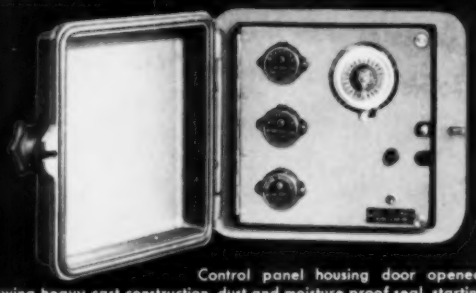
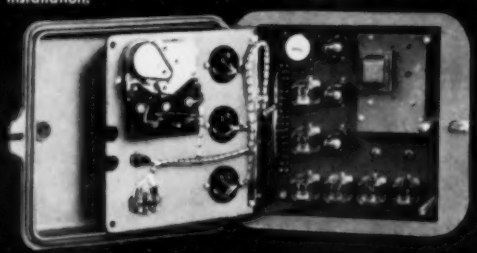


Engomatic POWER CONTROL SYSTEM

Typical Waukesha ***Engomatic*** Control System Installation on a Waukesha Long-Life Oil Field Unit. Note control panel can be mounted in any convenient position.



Control panel housing door opened, showing heavy cast construction, dust and moisture proof seal, starting reset, and time-cycle controls for an ***Engomatic*** pumping control installation.



Panel open, showing wiring harness, sealed relays and other electrical components, all of highest quality, and designed for long life and easy replacement.

423

The Waukesha *Engomatic* Control System meets the demand for internal combustion engine automation. All operation is independent of outside power. It is fully protected with safety shutdown devices and has visual indicators and manual resets, and functions with engines using all standard fuels. Operation can be controlled on a time-cycle basis; by remote control; liquid levels or temperatures; or by any signal peculiar to the equipment involved. Send for Bulletin 1731.

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Berea Sandstone target perforated by McCullough Super Casing Glass Jet. In supervised tests these jets obtained an average penetration of 9.208". Hole size in Berea Sandstone target averaged .850".

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mended torque, with a range of minimum-maximum values determined by the positions of the threads was adopted. This has been changed slightly from time to time and is now included in the American Petroleum Institute RP 5C1 (Care and Use of Casing). This reads in part:

"The optimum torque values shown in the following tabulation have been selected to give optimum make-up under normal conditions and should be considered as satisfactory providing the face of the coupling is flush with the last scratch or within two thread turns plus or minus of the last scratch.[1]

"If the make-up is such that the last scratch is buried two thread turns and the minimum torque shown in the tabulation is not reached, the joint should be treated as a questionable joint . . .

"If several threads remain exposed when the optimum torque is reached, apply additional torque up to the maximum shown in the tabulation. If the standoff (distance from face of coupling to last scratch) is greater than three thread turns when the maximum torque is reached, the joint should be treated as a questionable joint . . ."

As has been pointed out elsewhere,[2] no maximum torque has been or can be established. Field observation of a number of strings has indicated the following torques usually produce satisfactory results:

"Generalized" Tubing Torque Table

Size	*Minimum*	*Maximum*
2⅜-in. OD	**1000 ft lb**	**1400 ft lb**
2⅞	**1200**	**1600**
3½	**1500**	**2200**

This will vary with type of thread dope used, condition of pipe, other variables, even temperature.

It should be understood that this represents one torque program, and is not necessarily suggested as an industry-wide criteria

A prominent service organization reported its practice to an API committee as follows:

"Torque is not the sole measure of joint make-up, but should be used in conjunction with make-up position.

(a) If the average torque is reached at the time the coupling is at the last scratch, that is ideal.

(b) If the average torque is not reached when covering the last scratch, cover two turns if necessary.

(c) If covering the last scratch two turns does not develop the minimum torque, we recommend the connection be broken out.

(d) If the average torque is reached and several threads of the pipe remain exposed, proceed to the maximum torque. In the event the maximum torque leaves more than three threads exposed, we recommend the joint be broken out. It has been our observation that regular mill joints make up remarkably uniform."

Rent or Buy?

Convinced of the value of power tubing tongs, the contractor is immediately faced with the problem of tong ownership advantages versus tong rental.

It should be noted that the number of tong rental organizations is increasing, and this service is now available in practically all producing areas, in the U. S., Canada, and abroad. Prices of rental on single units range (in the U. S.) from $25 to $35 per day, and most rental firms establish a two-day minimum.

The cost of tongs for purchase ranges from about $3340 for the least expensive air-operated tong to approximately $6500 for the largest hydraulic tong, complete with hydraulic power unit. Most contractors are finding that in the long run, because of increasing demand for use of power tongs on more jobs, it is more economical to purchase.

Auxiliary Tong Uses

Power tongs are not only being used for screwing and unscrewing pipe threads, but are being used for unseating packers, drilling out plugs, bridges and cement. They have also been used successfully for reaming casing, and on one occasion is known to have drilled through 50 ft of cement at the bottom of a 5000 ft well.

Jaw attachments are available to work pipe ranging from 1.05-in OD to 5½-in. One piece of optional equipment permits the power tubing tongs to be used in stripping sucker rods.

Power Tongs — Tools or Instruments?

By the list of extra jobs that power tubing tongs are being called upon to perform, it is evident that the tools are not in the "fragile" classification. They may be considered as tools and not as instruments, and when operated according to manufacturer's specifications, using recommended lubricants and given normal care, they are extremely rugged.

In one case a tong was being used on a 10,000 ft hole and 9000 ft of 2-in. tubing was being rapidly lowered into the hole and accidently dropped — along with elevators and traveling blocks — on the tong. All that was required to restore the tong to operation and original shape was $2 worth of straightening.

In another instance a tong was being used when escaping gas caught fire. The fire burned the rig, the mast fell, and $35 in parts put the tong back in operation.

For these reasons, power tongs are becoming commonplace in nearly every producing locality — another standard piece of oil country equipment necessary to maintain oil production through safer, quicker and less expensive well servicing.

Acknowledgment

The author wishes to express gratitude to Lewis Foster, Foster Cathead Company, for assistance in preparation of this article, and to Byron Jackson Tools, Inc., and to Hillman-Kelley Oil Well Tools for illustrations and information included herein.

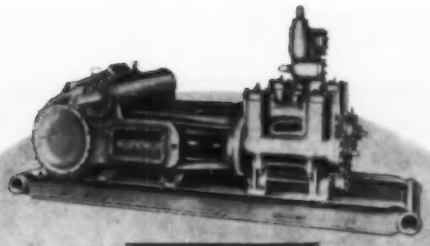
References

1. API RP 5C1, Supplement 2 to Recommended Practice for Care and Use of Casing, Drill Pipe, and Tubing, American Petroleum Institute, April 1954.
2. R. J. Stoup, Care of Tubing and Tubular Goods on the Lease, Proceedings of West Texas Oil Lifting Short Course, Texas Technological College, April 21-22, 1955.

★ ★ ★

The Author

Paul Teague, Jr., is sales manager and a partner in the Wichita Supply Company in Wichita Falls, Texas. Teague has served with that company, an industrial equipment supplier for several oil field equipment manufacturers, for the past 10 years. In recent months he has worked in close contact with power tong manufacturers, contractors and operators in the field of component parts manufacture, development and replacement.



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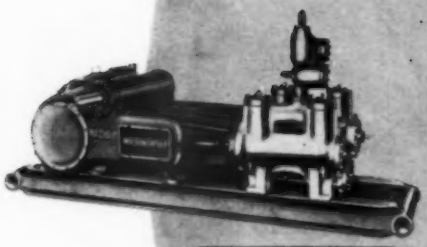

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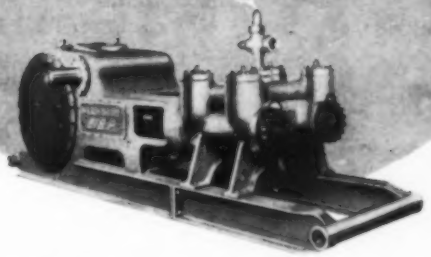

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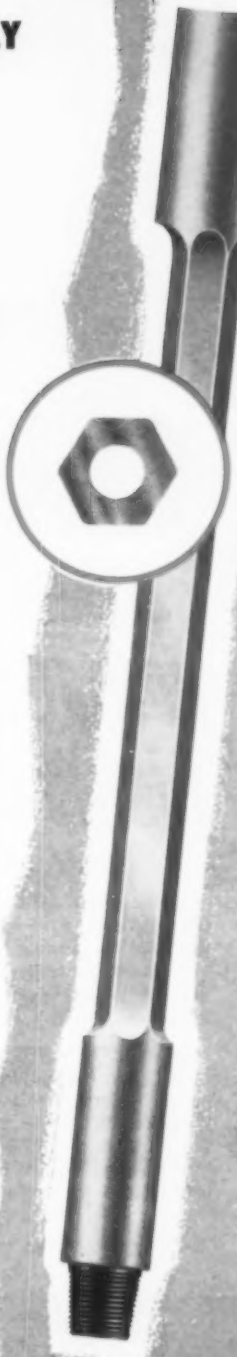

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	Tubing Failures Per Year	Iron Loss (Lbs/Day)	Tubing Failures Per Year	Iron Loss (Lbs/Day)
A	2	3.8	0	0.7
B	2	4.5	0	0.7
C	4	8.8	2	4.3
D	1	10.1	0	0.6
E	1.7	11.2	0	1.6
F	2	8.8	0	0.5
G	1.3	4.7	0	1.0
H	1.5	3.3	0	0.5
	15.5	55.4	2	9.9

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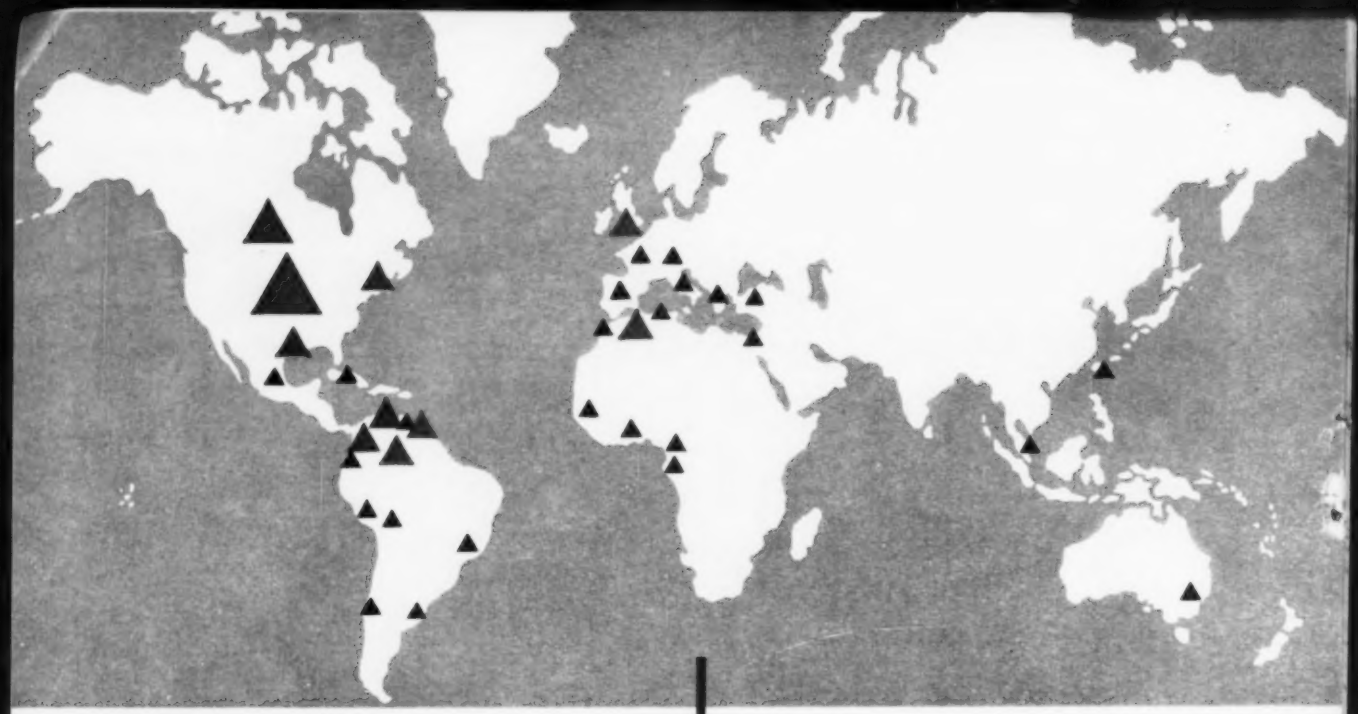

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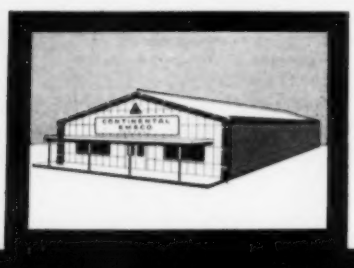

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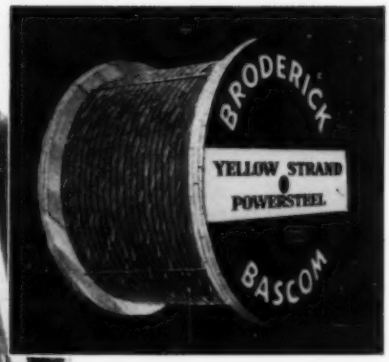

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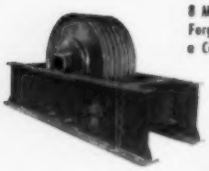

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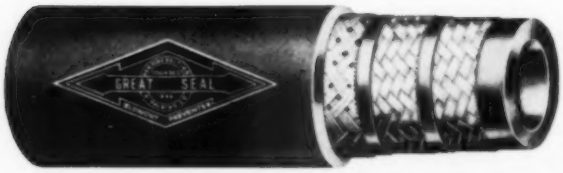

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Gas-Condensate Reservoirs

***Part 2** of a new fundamental series on gas-condensate reservoirs presents examples of reserves calculations and determination of gross value of recoverable reserves*

William C. Goodson
Republic Natural Gas Company
Dallas, Texas

Reserve Estimates

After the productive limits of the reservoir have been determined (6400 acres), and the formation evaluation has defined the necessary parameters, an initial in-place reserve estimate can be made. The reservoirs in this case are assumed to have the same thickness, water saturation, and porosity:

$$t = 25 \text{ ft}$$
$$S_w = 40 \text{ percent}$$
$$\phi = 25 \text{ percent}$$

Each reservoir is operating under depletion drive and has a liquid content (initial) of 22.0 bbl per MMcf. The reservoir pressure and temperature for each sand is as follows:

Depth —ft	Press. —psig	Temp. —deg F
4,000	1,800	150
8,000	3,600	180
12,000	5,400	220

Each reservoir is assumed to have the following compositional properties. Although it is well recognized that with pressure decline this composition will change, in the study it will be assumed to have a constant value throughout the life (Table 1).

TABLE 1. Composition of Reservoir Fluid and Separator Gas.

Components	Reservoir Fluid MOL.%	gpm	Separator Gas MOL.%	gpm
Methane	88.04	—	90.70	—
Ethane	5.76	—	5.65	—
Propane	2.60	0.713	2.30	0.564
Butanes	1.18	0.378	0.85	0.275
Pentanes	0.45	0.163	0.25	0.091
Hexanes	0.27	0.111	0.07	0.031
Heptanes plus	1.70	0.854	0.18	0.085
	100.00	2.219	100.00	1.046
Gravity	0.702			
CO_2 content	2.00		2.20	

In-place gas reserves. With the above information the in-place gas reserves can be determined volumetrically by the following formula:

$$V = 1545\ (\phi)\ (1 - S_w)\ \frac{P}{ZT} \qquad \text{(Mcf/acre-ft)}$$

where ϕ = Porosity, fraction
S_w = Water saturation, fraction
P = Initial bottom-hole pressure, psia
T = Bottom-hole temperature, deg F absolute
Z = Compressibility factor
(Deviation from perfect gas law).

The number of acre-feet productive in each reservoir is the same — 6400 acres times 25 ft or 160,000 acres-ft (Table 2).

TABLE 2. Calculation of Gas in Place.

Depth —ft	Press. —psig	Temp. deg F abs	Z (Comp factor)	Mcf/acre-ft	Gas in place MMMcf
4,000	1,800	610	0.822	830	133.0
8,000	3,600	640	0.870	1,500	240.0
12,000	5,400	680	1.030	1,780	285.0
					658.0

Condensate (in place). The condensate recoverable by normal temperature separation methods at initial conditions is 22.0 bbl per MMcf. This value is not altogether realistic since the liquid recovery will tend to increase with depth (Table 3).

TABLE 3. Calculation of Condensate In Place.

Depth ft	Gas in place MMMcf	Condensate in place bbl/MMcf	Condensate in place M bbl
4,000	133.0	22.0	2,930
8,000	240.0	22.0	5,280
12,000	285.0	22.0	6,270
	658.0		14,480

Recoverable gas reserves (to 800 psig abandonment pressure). The recoverable gas reserves for a depletion type gas condensate reservoir can be estimated or calculated in four manners:

a. Observing nearby reservoirs with equivalent depths and compositions;
b. Setting a terminal pressure and calculating reserves remaining at that time;
c. Plotting P/Z curve after considerable history has been developed;
d. Material balance taking into account retrograde behavior.

Of these four methods either (c) or (d) is the best and most accurate. Under initial conditions (b) is most generally used and (a) is used when very limited data is avail-

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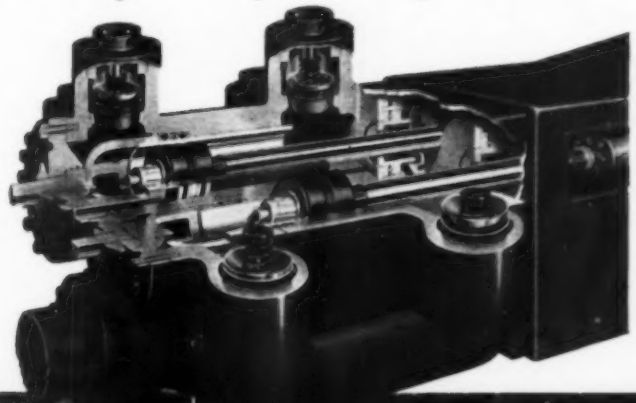

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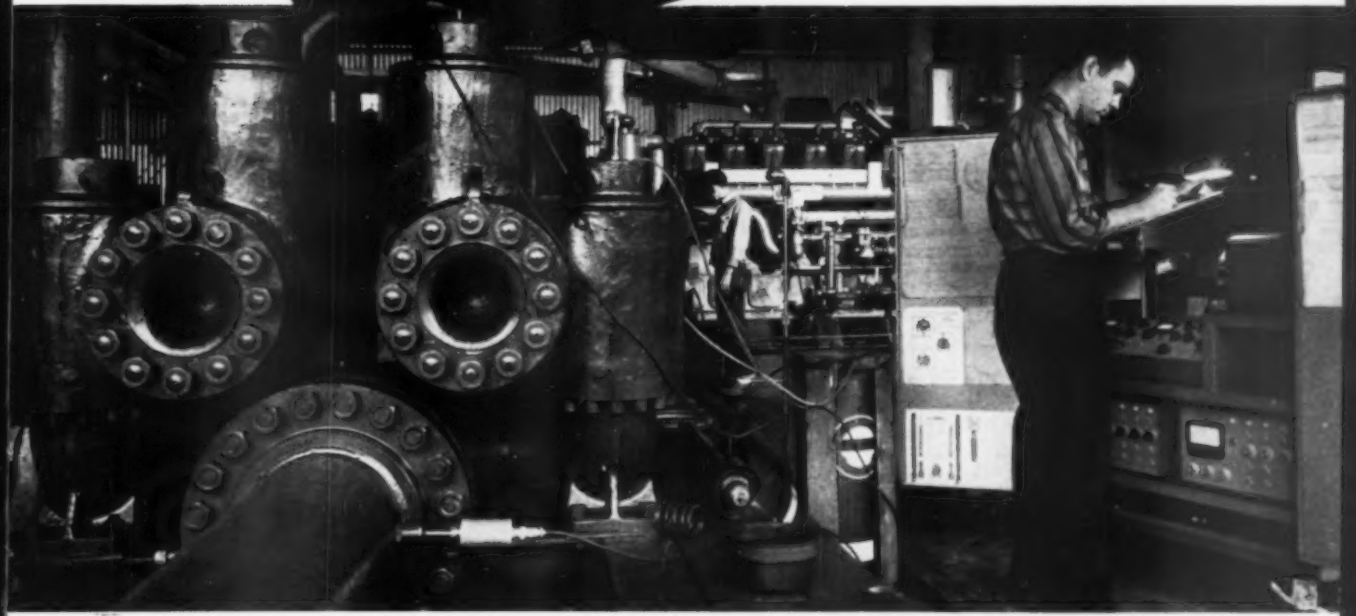

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TABLE 4. Recoverable Reservoir Gas Reserves.

Depth —ft	Bottom hole temperature —deg F	Z (Comp. factor)	Remaining Mcf/acre-ft	In-place Mcf/acre-ft	Recoverable Mcf/acre-ft	Reservior gas recoverable-MMMcf
4,000	150	0.92	340	830	490	79.0
8,000	180	0.88	330	1500	1170	188.0
12,000	220	0.86	320	1780	1460	233.0
					TOTAL	500.0

able and, at best, is only an approximation. Utilizing (b) gives the data in Table 4.

Recoverable condensate reserves. To estimate the total recoverable condensate over the field life is a complete study in itself. This value is very dependent on many factors. The possibility of cycling and its economics should be considered. In actuality, with major companies, months of effort, research, and testing would go into this consideration before a final decision would be reached as to how best to exploit a particular condensate reservoir of this size. For considerations of this problem, empirical relations must be considered. In view of our anticipated price for gas (15 and 20 cents per Mcf) cycling could be ruled out as not being economically feasible. Two other factors that help eliminate cycling are that (1) the reserve is too small, and (2) the condensate content is too low to justify the necessary capital expenditure.

Various field separation techniques are available — normal temperature stage separation, low temperature separation (mechanical), LTS (glycol), LTS (glycol) plus stabilization, quick-cycle dry bed units, full scale gasoline plant, etc.

From a quick look, LTS glycol plus stabilization is considered the most feasible for this problem. (This also requires much study from an economic and operational standpoint. These units are currently among the most universally adaptable for condensate systems. Recent investigation indicates that the quick-cycle dry bed desiccant units may have advantages under certain conditions.)

For the full life of the reservoir, these units (LTS glycol plus stabilization) will recover 10 to 15 percent more liquid than conventional separation.

To evaluate the overall condensate recoverable account must be taken of possible retrograde losses. Much work on retrograde problems has been done both by commercial laboratories and the oil company laboratories. The Bureau of Mines has just published a book that treats on this subject in great detail. It is possible to sample and test these reservoirs without too great expense. To evaluate these conditions properly this should be done early in the life of the field. In this study the factor for the cumulative stock tank recovery will be applicable. This will give a cumulative stock tank recovery of:

$$(\text{bbl/MMcf initial} \times (1 + \text{gain by glycol LTS + stab.}) \times \frac{\text{cum. avg. rec.}}{\text{(initial D.P. rec.)}} =$$

$$(22.0)\ (1.10)\ (0.45) = 11.4 \text{ bbl/MMcf.}$$

TABLE 5. Calculation of Condensate Recoverable.

Depth ft	Res. Gas Recoverable MMM	Condensate Recoverable B/MM	Condensate Recoverable M bbl
4,000	79.0	11.4	900
8,000	188.0	11.4	2145
12,000	233.0	11.4	2655
	500.0		5700

Table 5 presents a picture of recoverable condensate reserves in the reservoir.

Sales gas reserves and gasoline plant recovery. By consid-

TABLE 6. Basic Gasoline Plant Considerations and Product Value.

Component	Plant Inlet Gas Mol.%	Plant Inlet Gas gpm	Shrinkage & Loss Factor	Plant Rec. Factor	Plant Rec. gpm	Product Name	Product gpm
Methane	90.70						
Ethane	5.65						
Propane	2.30	0.564	0.94	0.75	0.397	LPG	0.412
Butanes	0.85	0.275	0.94	0.95	0.248	Butane	0.212
Pentanes	0.25	0.091	0.94	1.00			
Hexanes	0.07	0.031	0.94	1.00			
Heptanes+	0.18	0.085	0.94	1.00	0.195	12 lb RVP	0.216
	100.00	1.046			0.840		0.840

Product Value

Product	¢/gal.	Rec. gpm	(¢) (gpm)
LPG	3.0	0.412	1.236
Butane	4.0	0.212	0.848
12 lb RVP	8.0	0.216	1.728
	Total	0.840	3.812 or 4.53 ¢/gal avg

TABLE 7. Recoverable Products, Gas, and Condensate.

Depth—ft	Condensate M bbl	Plant Chg. (Reser. Gas) (0.94) MMMcf	Plant Rec. (Col 3) (0.840) MM gal	Sales Gas (Reser. Gas) (0.88) MMMcf
4,000	900	74.0	62.0	69.0
8,000	2,145	176.0	148.0	166.0
12,000	2,655	220.0	185.0	205.0
	5,700	470.0	395.0	440.0

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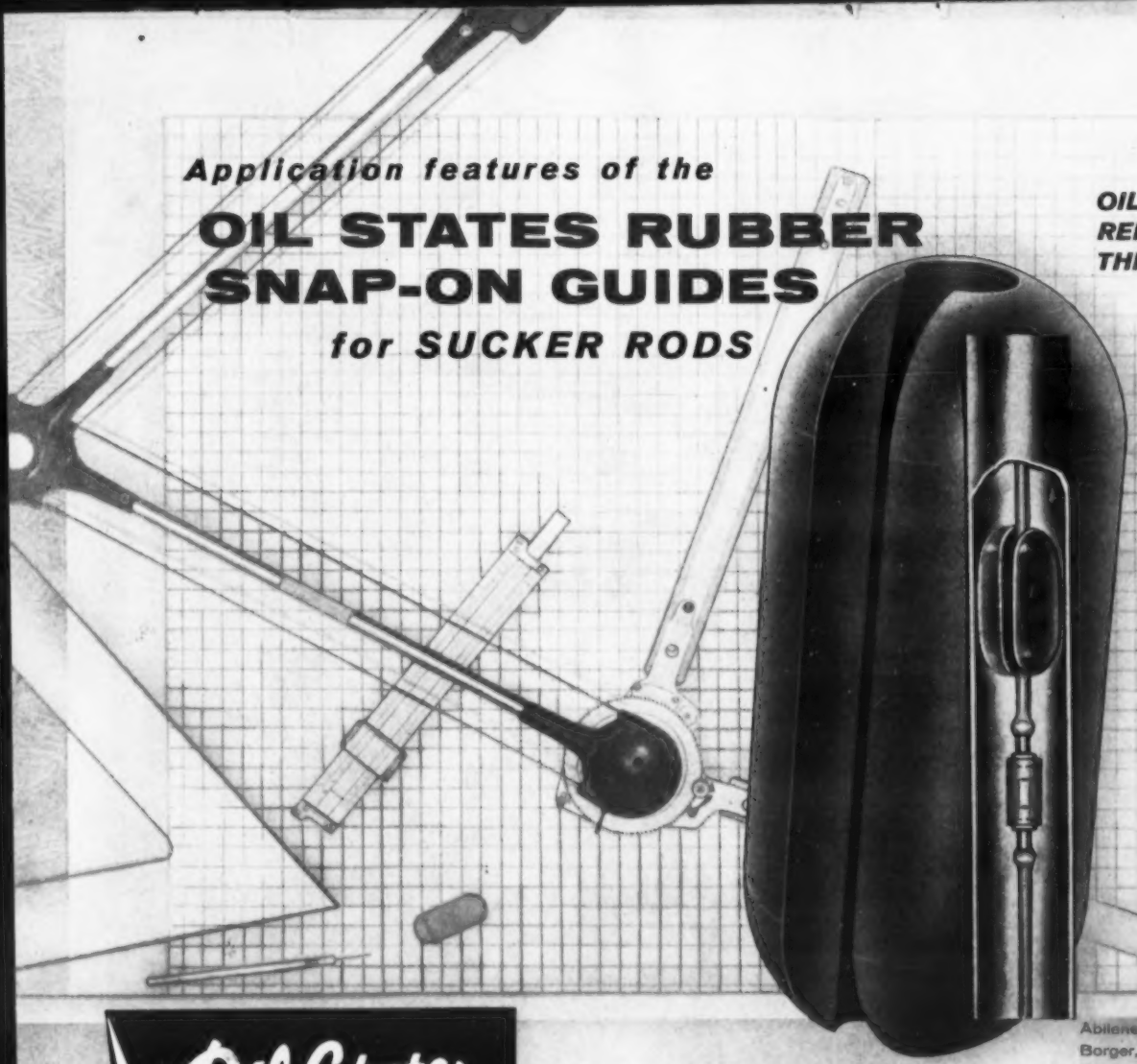

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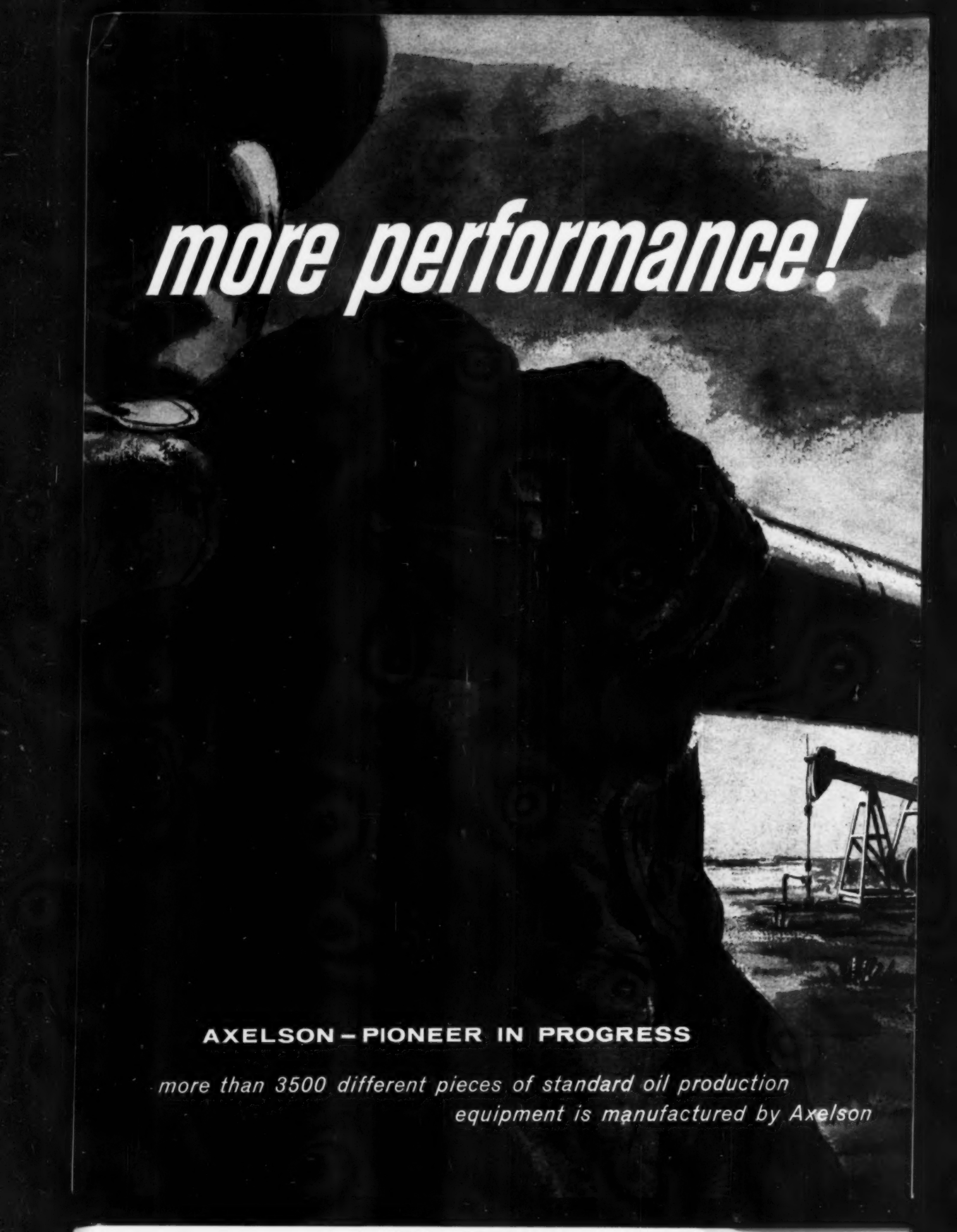
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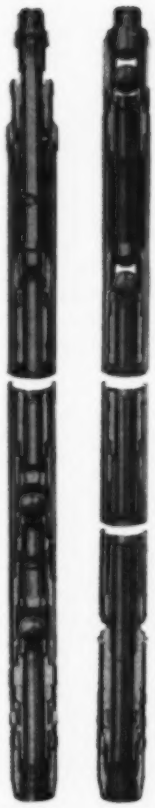

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ering shrinkage for condensate removal and gasoline plant recovery the sales gas reserves and overall liquid recovery can be evaluated.

	Percent
Shrinkage for condensate recovery	4.0
Loss for gasoline plant recovery	3.0
Loss for plant fuel	3.0
Line loss and unaccountable to plant	2.0
Overall shrinkage and loss	12.0

The gas composition available for gasoline plant processing after removal of condensate by field separation is given in the initial paragraph on reserves. As stated above, there is an average 4 percent shrinkage for condensate recovery and 2.0 percent line loss to the gasoline plant, or only 94 percent of plant recovery will be realized.

Assuming either the field operators or an outside interest installs an efficiently run gasoline plant, the following recovery factors can be anticipated:

Product	Recovery factor percent
Propane	75
Butanes	95
Pentanes plus	100

Based on conditions given in problem, this would result in an overall plant recovery as shown in Table 6.

Overall recoverable reserves. The ultimate recovery of condensate, plant products and sales gas is summarized in Table 7.

This is a summary of the recoverable salable products, gas, and condensate from these reservoirs under the methods that are going to be used to exploit them.

Gross Value of Recoverable Reserves

The gross value of the recoverable reserves involves estimation of future prices to be received for gas, condensate, and plant products. This will be discussed under the Gas Contractural Commitments portion of this study. The value of condensate can be forecast, but generally the actual price at the time the contract is made is used throughout the projected economic life. The value of the plant products, particularly butane and propane fluctuate all over the country, and are also subject to considerable seasonal variation. As more pipelines and underground LPG storage systems are constructed, these fluctuations will tend to stablize.

For purposes of this study, gas at three prices — 15 cents per Mcf and 20 cents per Mcf for interstate contracts and 10 cents per Mcf for an intrastate contract — condensate at *$3.25 per bbl*, and plant products as evaluated in the previous section at *4.53 cents per gal* will be utilized. This results in a gross value or revenue from these reservoirs as shown in Table 8.

TABLE 8. Revenue from Products, Gas, and Condensate.

	15c/Mcf	20c/Mcf	10c/Mcf
Sales gas—441 billion CF	$ 66,100,000	$ 88,200,000	$ 44,100,000
Condensate—5700 thousand bbl	18,500,000	18,500,000	18,500,000
Plant products—395 million gal	17,900,000	17,900,000	17,900,000
Total Gross Revenue	$102,500,000	$124,600,000	$ 80,500,000

This is the gross realizable value from these properties. The factors involved in placing either a net value on these properties or determining the profitability of either operating, selling or purchasing these properties will be discussed and evaluated in the remainder of this series. Obviously, such a problem is much too involved to consider any one facet in much detail.

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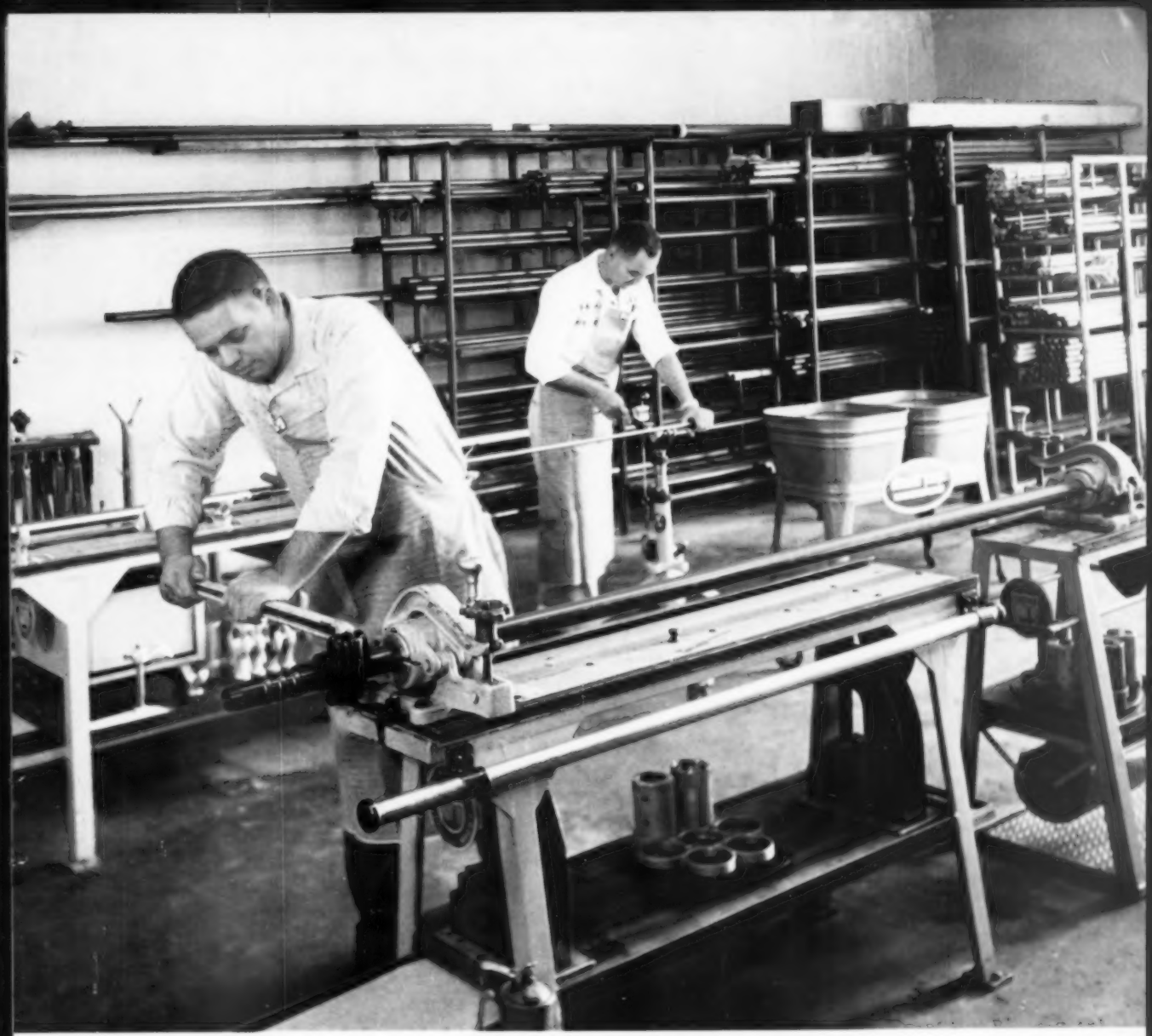

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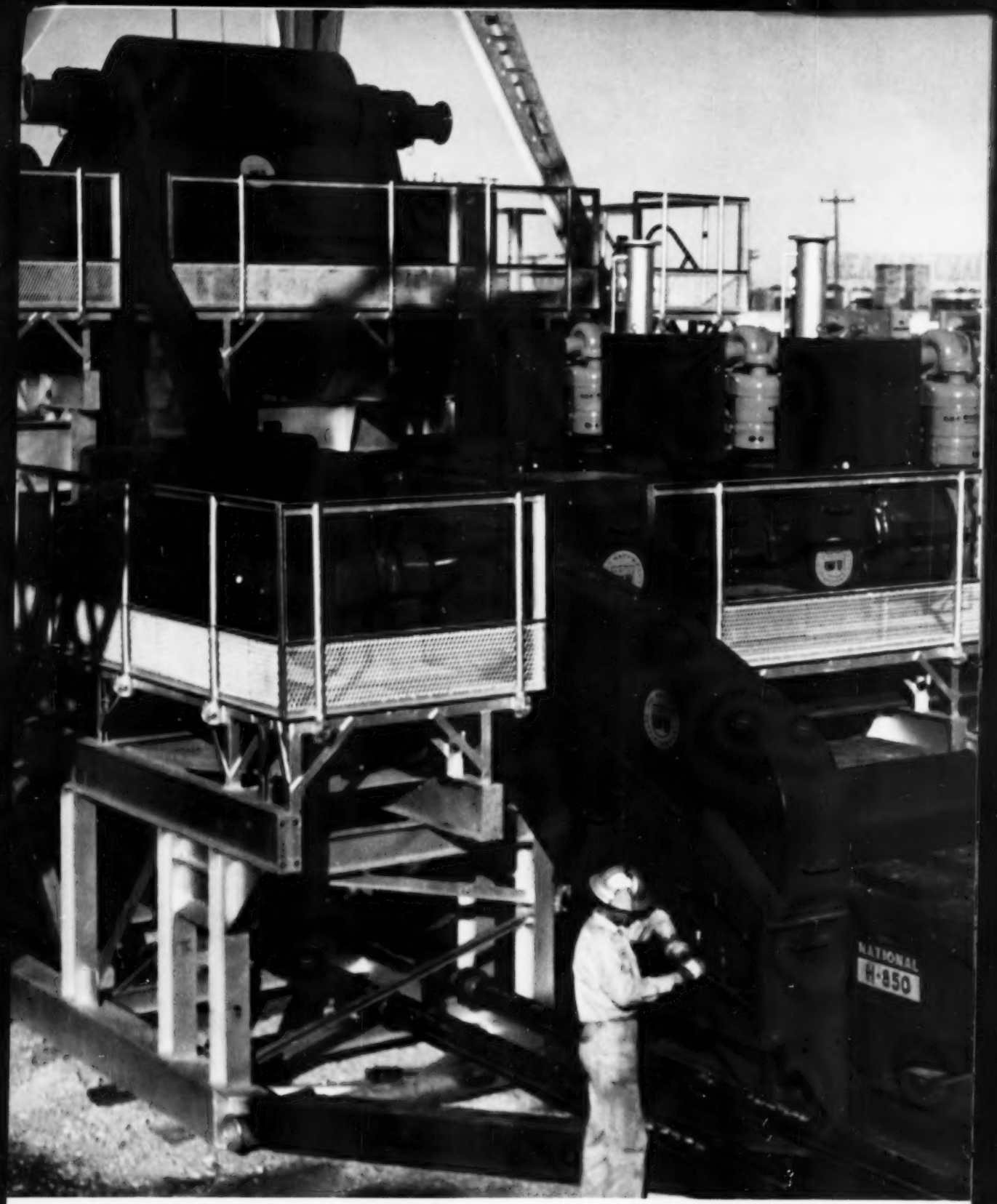

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OPTIONAL PUMP DRIVES—These include: Drives for one, two or three slush pumps; V-Belt or chain drives to the pumps; Single or two-speed pump drives.

NATIONAL DY-A-FLEX AIR CLUTCHES—Outstanding for rugged performance, these clutches are furnished for pump drives and, on rig drive groups, in the master clutch position.

AIR OPERATED CONTROLS—Air piping for controls is installed in the frames at the factory. Controls are conventionally located at driller's position for: engine throttles and clutches, pump drive clutches, master clutch and inertia brake, and (when specified) Gyrol fluid drive scoops. Upon request, extra control locations can be tailored for any requirement.

COMPLEMENTARY EQUIPMENT—Integrally mounted air compressor equipment for the rig control system is standard on National Drive Groups. Other drives for generators, dual air systems, etc. can be furnished to your specifications.

COMPLETE FACTORY TESTING—All National Drive Groups are assembled, lubricated and test run prior to shipment. Surfaces are protected by rust preventatives and all exposed surfaces are painted.

The National Representative in your area will be glad to give you more information on National Drive Groups, Rigs, and related equipment. Ask him soon.

National Auxiliary Drawworks Drive consists of a small fluid coupling, scoop controlled, mounted on a countershaft on the front engine frame. It permits all engines in a drive group **to operate as a single power unit while drilling.** But, at the same time, rotary speeds can be varied to meet all drilling needs.

A portion of the drive group for a National Type 55 Rig shows the National Torque Converter in operation. To protect the entire rig from shock loadings, National recommends the use of torque converters or hydraulic couplings.

More on the next page...

National Supply offers a complete rig-up service which insures faster starts in the field. Equipment boxed for export shipment is specially wrapped, sealed and weatherproofed against the conditions of passage and dock storage.

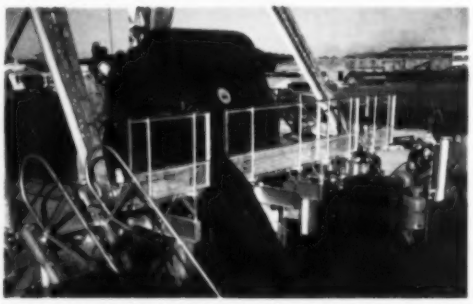
Save time and money with NATIONAL's rig-up service!

There's a *sure way* to be *fully* prepared for a new drilling job anywhere in the world—and National Supply's optional rig-up service provides it.

In either of our two special port center rig-up yards or your own equipment yard, we assemble—or direct the assembly of—the complete rig. Everything is positioned exactly as it will be used overseas. Then we test-operate, lubricate and adjust all components. Any problems that may cause initial delays at the well site are promptly solved. If you desire guide photographs and paint-coded parts for re-assembly, these are also supplied.

You can see how this rig-up service pays off for operations in remote areas, where services and parts are often days away. But it is also important for rigs closer to home—where even a short delay boosts estimated operating costs.

National has performed this time-and-money saving rig-up service for many years. We have a big list of satisfied customers who report *better rig-up time this way than with previous field assemblies*, and we will be glad to give you more details. Just contact the National representative in your area or our Export Division office in New York City.



If you desire guide photographs of machinery connections and paint-coded parts for re-assembly, these are also supplied.

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Litho in U. S. A.

JET DEFLECTION

. . . A recent advancement in directional drilling

Roy P. Dwyer
The California Company
Venice, Louisiana

New hole deviation tool saves time, trims special equipment expense, promises more controlled directional drilling — with certain limitations.

"JET DEFLECTION" is a new method of deflecting a well bore which, in certain situations, results in considerable savings.

The method was devised to eliminate the time-consuming practices of using more conventional tools. A conventional jet bit is used with all but one jet restricted, and this one jet of as large a diameter as the hydraulic system will permit. By eroding the well bore on the side and bottom in which the large orifice is oriented, the bit tends to deflect in that direction. After the proper course is established the same bit is used to drill ahead.

The jet-deflection method has reduced the time required to drill surface holes by two thirds, and wells are being directionally drilled in only a few days more than a straight hole.

When the deflection is small the hole may be deviated and straightened up in the surface hole at slight additional cost over a straight hole.

Only conventional bits have been used, with variations in the jets. However, it is believed that the range of usefulness of this method can be extended by the development of special bits and tools more adaptable to jet deflection.

Deviation Tools

In recent years, controlled directional drilling has become an important factor in the economical exploitation of reserves which lie under inaccessible or very costly surface locations. With the advent of offshore development of the tidelands and the increase in townsite and river-bottom drilling, a boom in directional drilling has occurred.

Until recently the conventional means of deflecting a bore hole consisted of using three types of equipment: The whipstock, the spud bit, and the knuckle joint. All of these methods require considerable lost time as a result of tripping, changing bottom-hole assemblies, and circulating to condition the hole. Additional equipment in the form of bits, hole-openers or pilot reamers, substitutes, small drill pipe, and monel pup joints are required.

Several possible hazards are involved when using the older tools, the most serious of which is sticking the whipstock. When this occurs and the tools cannot be jarred loose, a costly fishing job usually results.

A second danger when using a whipstock is the premature shearing of a shear pin, which is a frequent occurrence when running a whipstock in the hole.

A third risk involved is the possibility of being unable to get into the rat hole after setting the drilling off of a whipstock.

The last undesirable factor involves the course of a hole drilled with tools which have a predetermined deviation built into them. The hole must be drilled until the course is a tool set-off and then a tool run. This often results in severe dog-legs which can later interfere with drilling and completion.

As the conventional tools in use were both time-consuming and risky, an improved method of gaining the objective was needed.

Jet-Deflection Method

The jet-deflection method has been developed and used to accomplish the deviation of a bore hole at a minimum cost. This method allows a full gage hole with gentle changes in direction and deviation to be drilled with savings in time, bits, and extra equipment, and without the hazards of the older conventional tools.

As the non-magnetic drill collar is always in the bottom-hole assembly, the hole can be surveyed with confidence at all times regardless of the angle or direction. As deflection is accomplished with a conventional bit and bottom-hole assembly, trips are considerably less frequent.

The conception of this method was based on the knowledge of the tremendous energy available in a fluid jet stream and the idle hydraulic horsepower at hand on a rig. Although some rigs are handicapped with small pumps and prime movers, more and more are changing to larger pumps in order to drill more efficiently in all circumstances.

Development of Jet Deflection

The initial field trial was made with a standard three-cone soft-formation bit in which was installed one 7/8-in. jet and two blank jets. The bottom-hole assembly consisted of an extension sub, near-bit full-gage stabilizer, and a non-magnetic pup joint. Three hundred hydraulic horsepower was available resulting in 1050 psi with the bit at 700 ft. The formation was soft plastic shale or gumbo. After 30 ft of jetting and drilling, 8¼ deg of angle was noted and subsequently reduced. Even though the initial field trial was made in a reduced hole that had to be reamed to full gage, a 25-percent reduction in the time to drill the surface hole was noted.

As the principle had now been proved, the following improvements were successfully made, not necessarily in the order listed.

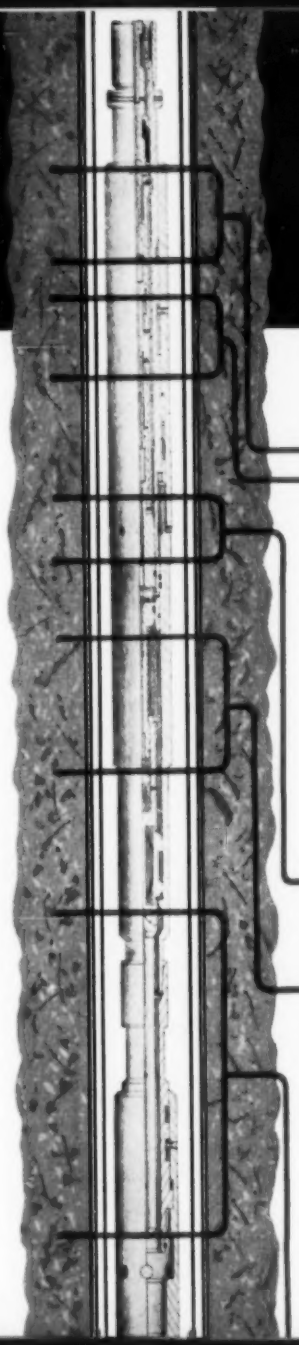
1. A full-gage hole drilled with two of the three jets plugged. However, this necessitated trips to pick up drill collars.
2. Two small jets (¼ or 1/8 in.) and one large jet (¾ or 7/8 in.).
3. A conventional drilling assembly with all drill collars and stabilizers. This is the normal bottom-hole assembly in use today.

Presented under the title "Recent Advances in Directional Drilling" at the spring meeting of the Southern District, API Division of Production, March 25-27, 1959, New Orleans, Louisiana.

NEW

JOHNSTON TESTERS FULL-BORE TEST AND COMPLETION TOOL

Now, you can make all the savings in round trips and rig time that result from using a combination test and completion tool without the disadvantages that sometimes result.



NEW

THE UNIQUE LOCKING SYSTEM makes it possible for the testing valve assembly to hold pressure in either direction; therefore, tubing or drill pipe may be pressured-up at any time while going in the hole without the use of any additional equipment.

TEST VALVE IS EASY TO OPEN—Simply pick up on tubing, torque slightly to the right and set down. The action is positive and there is no chance of "getting lost" by extensive rotation.

VALVE SYSTEM OFFERS MANY ADVANTAGES—**First,** initial shut-in pressure can be taken very quickly with only a minimum flow of formation fluid. **Second,** since the test valve closes before the circulating valve opens, mud from the annulus cannot contaminate the formation. **Third,** valuable rig time is saved because you can reverse circulate while taking shut-in pressures. This "circulating" feature also keeps sediment from collecting on top of the testing valve assembly for easy retrieving.

EXCLUSIVE JOHNSTON TESTING VALVE ASSEMBLY is rugged and dependable. Because of the valve arrangement and the recording assembly, you can take as many bottom hole shut-in pressures as you want without returning test section to surface. This means more information from your test. Later tests may be made by simply pumping the test section back in place.

***No rotation is necessary* with this tool during drill stem testing operations.**

You can take as many bottom hole shut-in pressures as you want without returning the testing valve assembly to surface.

You can also squeeze cement, re-perforate, fracture or acidize without ever pulling the tubing or drill pipe.

Then, if you need later tests, you can pump the pressure test section in place without ever making a round trip.

You can do all these things with full assurance that you are using a positive tool that is completely safe in operation. There is no guesswork. All operations involve simple up-and-down movement or a minimum of right hand rotation. No damage results from excessive rotation. No left hand rotation is ever required.

After all operations are completed, a built-in jar assures packer unseating when unseating is desired.

In addition, this tool is backed by Johnston Testers —the largest operator in the field of drill stem testing. You get all the advantages of Johnston's unparalleled experience when you specify the *Johnston* Test and Completion Tool. Fill out the coupon or drop us a note on your letterhead for full information. Please refer to bulletin number A.62

Please send me complete information on the New Johnston Full-Bore Test and Completion Tool.

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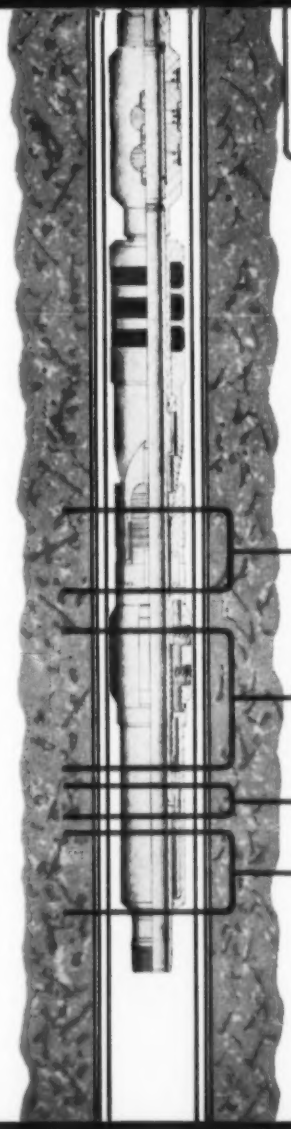


JOHNSTON TYPE "T" PRESSURE RECORDER gives unfailing accuracy, sensitivity and dependability under all testing conditions. This recorder is built to withstand unavoidable oil field jolts and is not apt to be knocked out of calibration. Non-tension type recorders may.

TWO-WAY ANCHOR SLIPS enable the operator to take a strain on the tubing without unseating the packer.

BUILT-IN JAR makes it easy to unseat packer. As in all other operations, no left hand rotation is required to operate or reset.

SIMPLE SETTING OF PACKER. Just pick up, torque to the right and slack-off, and the packer is set. The by-pass valve, which is closed when the packer is set, has a simple and positive opening and closing action.

FULL OPENING THROUGH TOOL (when testing valve assembly is out) permits perforating, squeezing, and other operations without difficulty.

PATENTS APPLIED FOR

JOHNSTON TESTERS, INC.

P. O. BOX 98

HOUSTON 1, TEXAS

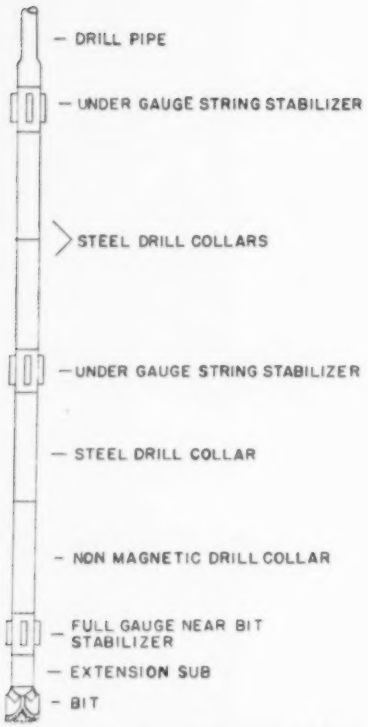


FIG. 1. **Jet deflection assembly** is only slightly different from conventional drilling string makeup. At the bottom of the drill collar string is a full-gage, near-bit stabilizer, extension sub and non-magnetic pup joint.

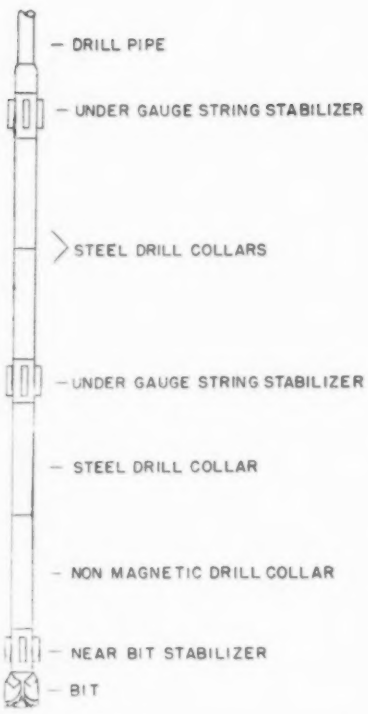


FIG. 2. **Normal drilling assembly** is only slightly different from jet deflection makeup. In jet-deflection method, however, it is not recommended that drill collars with diameters in excess of 70 percent of the hole diameter be used.

Field Practice

It is now common practice to run a jet-deflection bottom-hole assembly if the deflection point is to be reached before dulling a bit. If the hole is to be deflected in the surface hole, the jetting assembly is made up (Fig. 1) and used to drill out the cement in the conductor pipe as well as any hole necessary to reach the deflection point. The same will hold true below surface pipe if only a few hundred feet of hole is to be drilled before jetting. When the deflection point has been reached, the large jet (Fig. 3) is oriented in the desired direction and maximum circulation is established.

In actual practice smaller rigs can parallel their pumps while the bit is on bottom. The bit is lowered to bottom and all practical weight is put on the bit. Circulation is thus maintained for an appropriate length of time, depending upon the nature of the formation. The bit is lowered to bottom and all practical weight is put on the bit. Circulation is thus maintained for an appropriate length of time, depending upon the nature of the formation. The bit is occasionally slowly reciprocated in order to erode the wall of the hole and allow the bit to move in the desired direction.

In harder formations it is sometimes necessary to jet 15 to 20 deg either direction from the proposed direction in order to obtain enough erosion to allow the bit to deviate. One to 10 ft are then drilled before the jetting operation is repeated.

Drill collars with diameters in excess of 70 percent of the hole diameter are not recommended for deflection as they tend to be too rigid to allow the bit to deflect even though proper erosion is obtained from jetting. When it is realized that a ¼-in. horizontal deviation in 2½ ft of vertical penetration will result in a change in angle of ½ deg, it is easy to see just how little erosion is needed to accomplish a change in direction or angle.

Field Results

On routine wells in the Louisiana Gulf Coast area with normal deflection angles of 15 to 20 deg, a directional hole can be drilled in 15 to 20 percent additional time over that required to drill a straight hole if the deflection point is not too deep. Higher or lower angles may require more time, as the angle is more difficult to maintain at higher angles and the direction tends to drift more at lower angles. In one field where 15½ days are required to reach total depth, the average time to drill a directional hole is 17 to 20 days.

Two wells drilled recently offshore with the same drilling rig from the same location will serve as a good example. A straight hole was first drilled to 7250 ft in 9½ days with 99 rotating hours and 5 bits being required. A directional hole was then drilled with the objectives being to be out 2050 ft at a true vertical depth of 4450 ft and 3765 ft out at a true vertical depth of 7250 ft. Both objectives were attained in 14½ days requiring 141 rotating hours and 7 bits, even though 1050 ft more hole were drilled than for the straight hole. The hole was deviated at 500 ft, the direction and angle obtained, and surface casing set through the buildup. It was necessary to jet between 4000 and 4700 ft in order to correct direction. Otherwise the hole was drilled to total depth without the necessity of further changes in course.

Reference to Tables 1 and 2 will reveal the economies to be realized by

TABLE 1. Relative Costs for a Deflected Surface Hole.

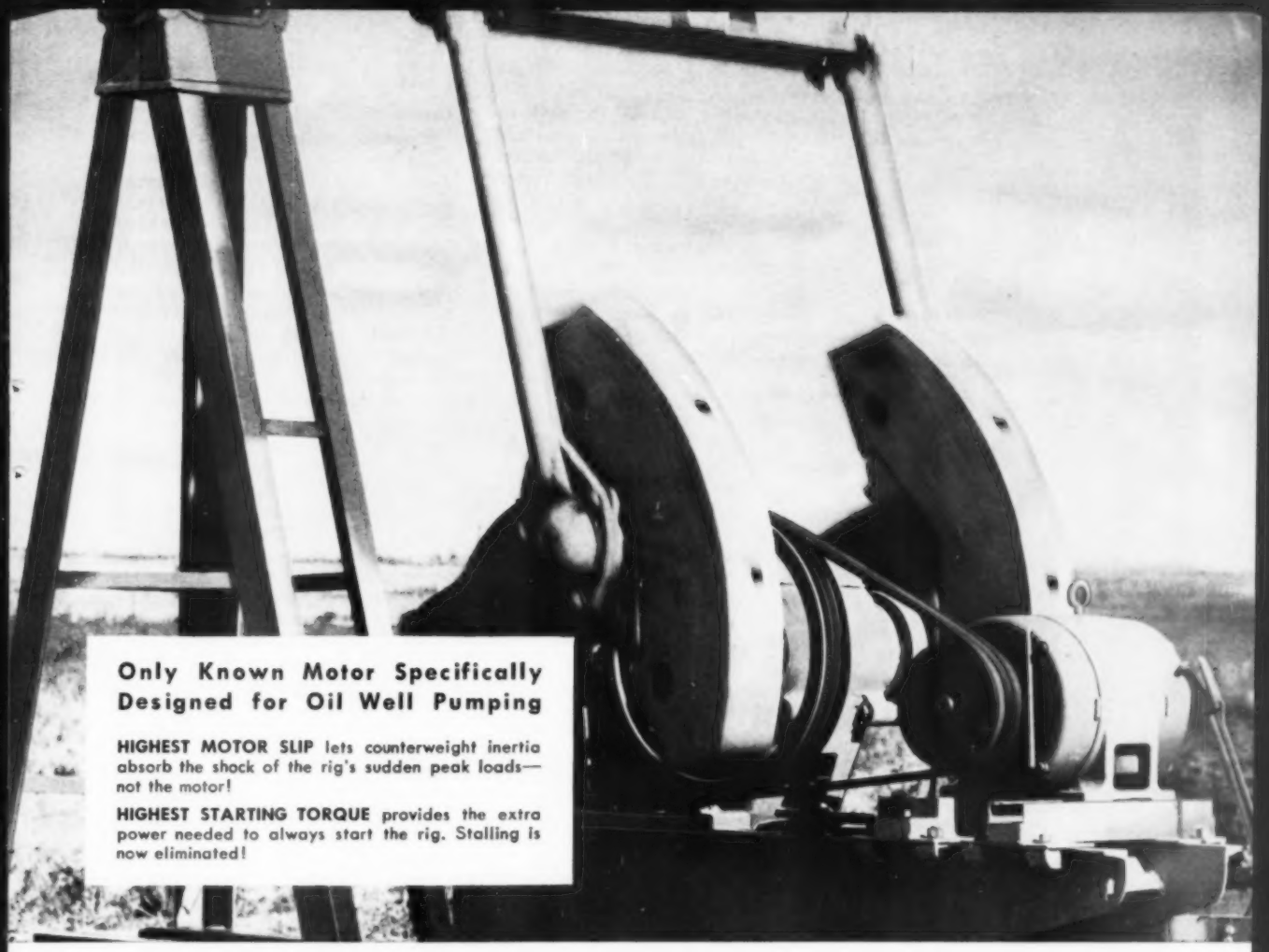
	Jetting	Whipstock
Contract drilling*	$1860 (30 hours)	$5520 (90 hours)
Directional services	705	1170
Bit and hole openers	540	1710
Stabilizers	710	880
Non-magnetic drill collar	75	150
Substitutes	60	180
Supervision	100	200
	$4050	$9810

*Based on a $1450 per day rig. NOTE: Mud cost not included.

TABLE 2. Relative Costs for 3000-ft Deflection at 10,250 True Vertical Depth.

	Jetting & Whipstock	Whipstock Only
Contract drilling*	$32,000	$56,000
Directional services	3,640	6,100
Bits and hole openers	4,215	6,260
Stabilizers	1,100	1,500
Non-magnetic drill collar	650	1,350
Substitutes	200	500
Supervision	900	1,700
	$42,705	$73,420

*Based on a $1450 per day rig. NOTE: Mud cost not included.


Only Known Motor Specifically Designed for Oil Well Pumping
HIGHEST MOTOR SLIP lets counterweight inertia absorb the shock of the rig's sudden peak loads—not the motor!
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Eight- to ten-percent slip—highest of any oil well pumping motor—lets the rig's inertia smooth out load and current peaks that often damage ordinary motors and cause voltage fluctuations. This means lowest kw-hr cost per barrel pumped!

Four-hundred-percent (400%) starting torque gives General Electric's new Type KOF the extra power needed for dependable starting on unattended rigs. Highest starting torque prevents stalling and costly motor burnout!

No other motor has been designed so completely around the requirements of the oil well pumping application. For the full story call your authorized motor distributor or nearby Apparatus Sales Office; or write direct to Section 899-4, General Electric Co., Schenectady 5, N. Y.

Compare General Electric's New Type KOF Motor

	Starting Torque	Motor Slip	Double-end Ventilation	762-volt Connection	Regreasable Design
General Electric (Beam-type Pumping Motor)	High	8-10%	Yes	Yes	Yes
Manufacturer "A" (NEMA C)	Low	2-3%	No	No	No
Manufacturer "B" (NEMA D)	Med.	5-8%	Yes	No	Yes
Manufacturer "C" (NEMA D)	Med.	5-8%	No	No	No

Progress Is Our Most Important Product

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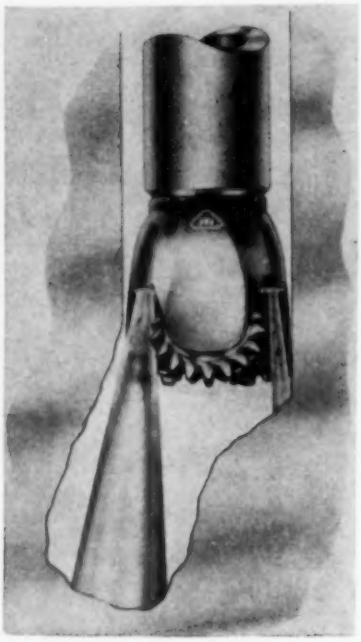


FIG. 3. **Special three-cone bit** illustrating principle of jet-deflection. On bottom, all practical weight is placed on bit and hole is circulated. Occasionally bit is slowly reciprocated to erode the wall of the hole and allow bit to move in the desired direction.

the utilization of the jet-deflection method wherever possible. Table 1 shows the average of costs of deflecting and drilling a 15-in. surface hole using the jet-deflection method, as compared with using a whipstock. The figures used are averages of several wells and should reflect day-to-day economies to be expected. It should be noted that drilling fluids are not included in the breakdowns, as the daily costs of treatment vary greatly from field to field. Table 1 is included as conditions are more nearly the same so that the comparison should be more nearly exact. Table 2 shows the drilling costs for a 10,250-ft true vertical depth well. In some of the wells included under the jet-deflection method, one or two whipstocks were required at deeper depths. The major factors involved are days required to drill and the equipment involved.

Double dog-legging. The jet-deflection method has proved to be a valuable means of double dog-legging a hole. This requires the deflecting, drilling, and straightening of a bore hole in order to penetrate the producing zone or zones vertically. Casing usually is run after the hole has been straightened and the rest of the hole drilled normally. Appreciable savings can result from this practice.

Recently, 40 hours were required to deflect a well 175 ft, whereas 15 hours are normally required to drill the same hole straight. It is estimated that a minimum of 4 days would have been required to accomplish the same objective with a whipstock.

Side-tracking off plug. Another practical use for the jet-deflection method is in side-tracking off of cement plug or from the low side of a directional hole. This is accomplished in the same manner as deflecting or changing the borehole direction. The bit used to "dress off" the cement plug can be used for deflection if the proper-size jets are installed and oriented before running the bit.

Approximately 6 hours have been required to sidetrack off of a cement plug. In the case of an uncontrolled sidetrack in a straight hole where direction is unimportant, it is not necessary to even run a non-magnetic drill collar.

Hazards

No instances are known of to date in which a fishing job has resulted from the use of the jet-deflection method. However, the use of stabilizers in the drill-collar string is considered essential to prevent the differential sticking of the collars while jetting on bottom.

Limitations

Excellent results have been obtained using the jet-deflection method to a depth of 6000 ft. However, at this point the successful application decreases with increased depth. Good results have been obtained to a depth of 8500 ft with a conventional bit, but not with the consistency desirable. The factors which probably influence the erosion are decreasing bit hydraulic horsepower, harder formations, and the cushioning effects of the hydrostatic head on the jets.

The hydraulic horsepower available on a rig is a big factor in the speed with which a bore hole can be deflected and sometimes in the success of the operations. An absolute minimum of 400 available hydraulic horsepower can be used at shallow depths; however, unreliable results may occur. At least 700 available hydraulic horsepower is recommended to obtain good results successfully and consistently.

The ability of the directional operator is a bigger factor in the efficient use of the jet-deflection method than with conventional tools. He must develop a technique of jetting which is not required when using a whipstock. His selection of the proper bottom-hole assembly for a given situation is of utmost importance, with success or failure being dependent thereon.

Considerable difficulty was encountered originally with the erosion of the approach hole leading to the larger or orienting jet because of the relatively large volume of fluid flowing through the approach. This situation has now been generally overcome by enlarging the approach hole (Fig. 4) and cementing the jet in place.

Future of Jet Deflection

Practically all work to date using the jetting method has been done using a modified conventional bit. It is believed that the operational depths can be greatly increased by the development of bits more adaptable to the method. Of prime importance is the location and position of the orienting jet with respect to the bottom of the hole. As more knowledge is required of the action of a jet stream in a high-pressure fluid atmosphere, the practical extension of the efficient use of this method will be extended.

Acknowledgment

The author wishes to express appreciation to The California Company and to California Research Corporation for the release of and permission to present this paper. U. S. Patent No. 2,873,092 was issued on the method February 10, 1959. Licenses under the jet-deflection method patent are available on a non-exclusive basis from the latter. ★ ★ ★

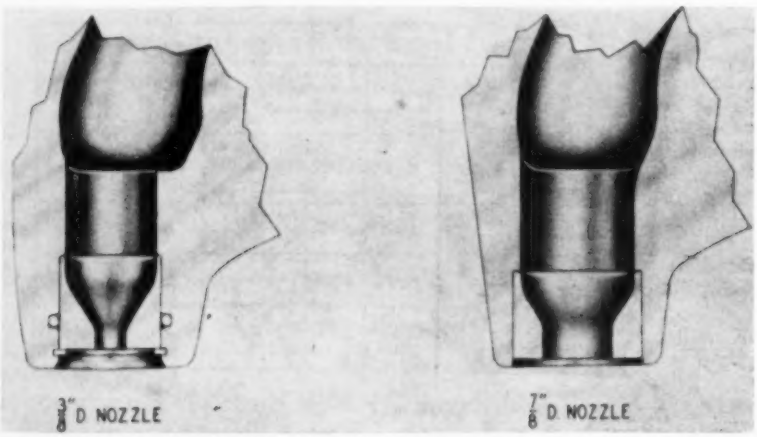
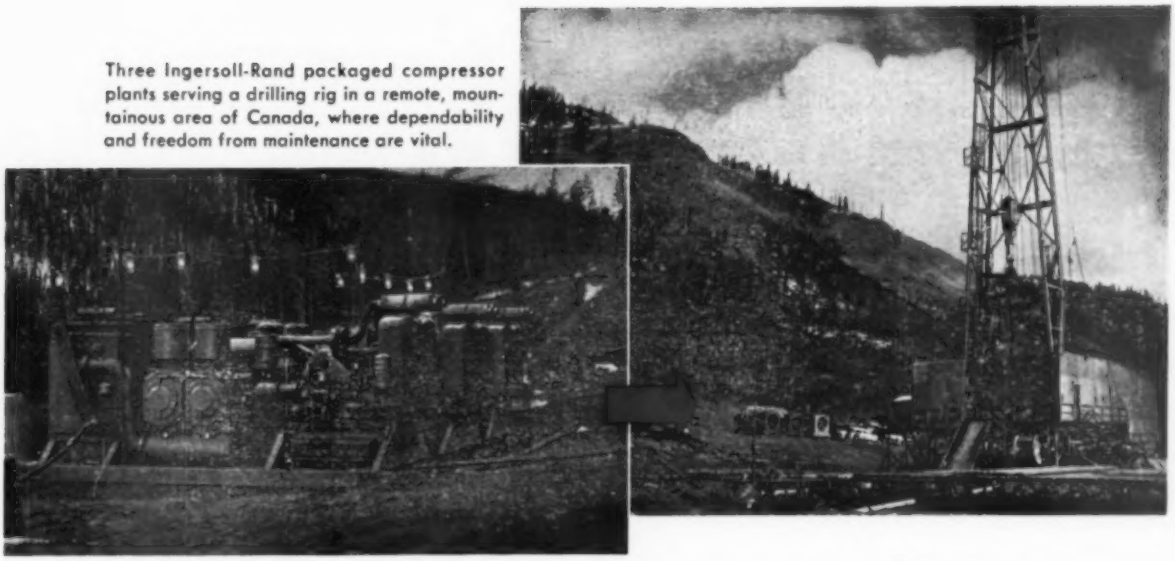


FIG. 4. **Cross section comparing nozzles** in bit designed for jet deflection. One large jet (from ¾ to ⅞-in.) and two smaller (⅛, ¼, or ⅜-in.) jets are used.

Three Ingersoll-Rand packaged compressor plants serving a drilling rig in a remote, mountainous area of Canada, where dependability and freedom from maintenance are vital.



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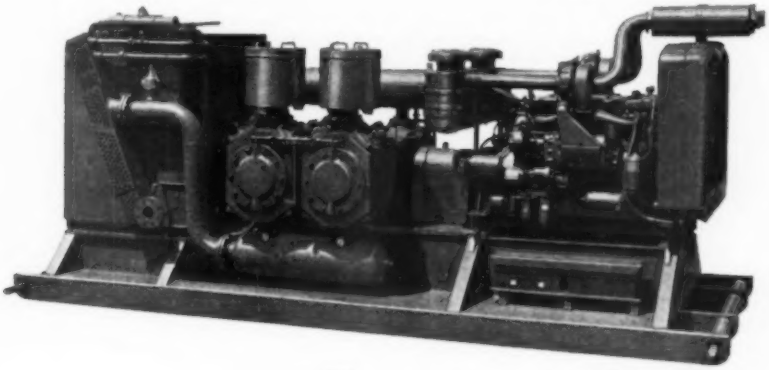

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ALASKA:

Swanson River Field Development

Companies, contractors agree — operations are costly and cold

Cameron Edmondson, *Anchorage, Alaska*

THE MOST remarkable thing about the Standard Oil Company of California-Richfield Oil Company, Union Oil Company of California and Ohio Oil Company operation in the Swanson River field of Alaska has been the absence of exceptionally unusual problems commonly associated with such remote wildcat exploration. Compared to Humble Oil Company's Bear Creek venture, the Kenai Peninsula wells are relatively routine drilling jobs.

In fact, weather conditions are comparable to those in some of the Rocky Mountain area and drilling compares to that of the Julesburg Basin.

The only serious and expensive trouble encountered thus far was a stuck drill string on the No. 3 well. This happened when the tool failed to open on a formation test. Ultimately the pipe stuck and then parted, under pulling tension, just below the elevators. When considerable efforts to fish the string failed, it was decided (because it had been drilled to total depth and no production was indicated) to plug and abandon.

Aside from the sheer good fortune of operating in an area with relatively stable climate, several factors are necessary for smooth progress. Among these are logistics of supplying the operations with everything necessary for any foreseeable emergency.

Supply Inventory

Coastal Drilling Company rig carries a full line of wash pipe, washover shoes, sockets, jars and bumper subs for fishing jobs.

Although primary service companies have moved into Alaska and supplies are becoming available, stockpiles of expendable supplies are still being maintained at the locations. From 200 to 800 tons of mud are kept at the wellsite, stored on pallets and wrapped in vinyl plastic.

Steam wreathes the winterized rig drilling the No. 4 Swanson River well. As viewed from across a frozen slush pit the fuel storage tanks can be seen at left center. The tanks hold up to 40,000 gal of diesel to see the rig through any transportation breakdown. Behind the end tank is the boiler house with its smoke stack silhouetted by a cloud of steam.

Fuel tanks store 40,000 gal of diesel oil, furnishing a firm reserve at breakup time. Each well is spudded with more than 100 bits on hand — considerably more than the average number required per well thus far. Also, thousands of feet of casing are on pipe racks located at the No. 2 well.

Finally, to assure a trouble free supply of drill water, a 125 to 150 ft water well is drilled for each location.

Coastal Rig

Also contributing to the relatively uneventful operation has been the contractor's use of a thoroughly field-tested rig and fully experienced crews. The result has been a negligible amount of down time and a very low personnel turnover during nearly three years of operation.

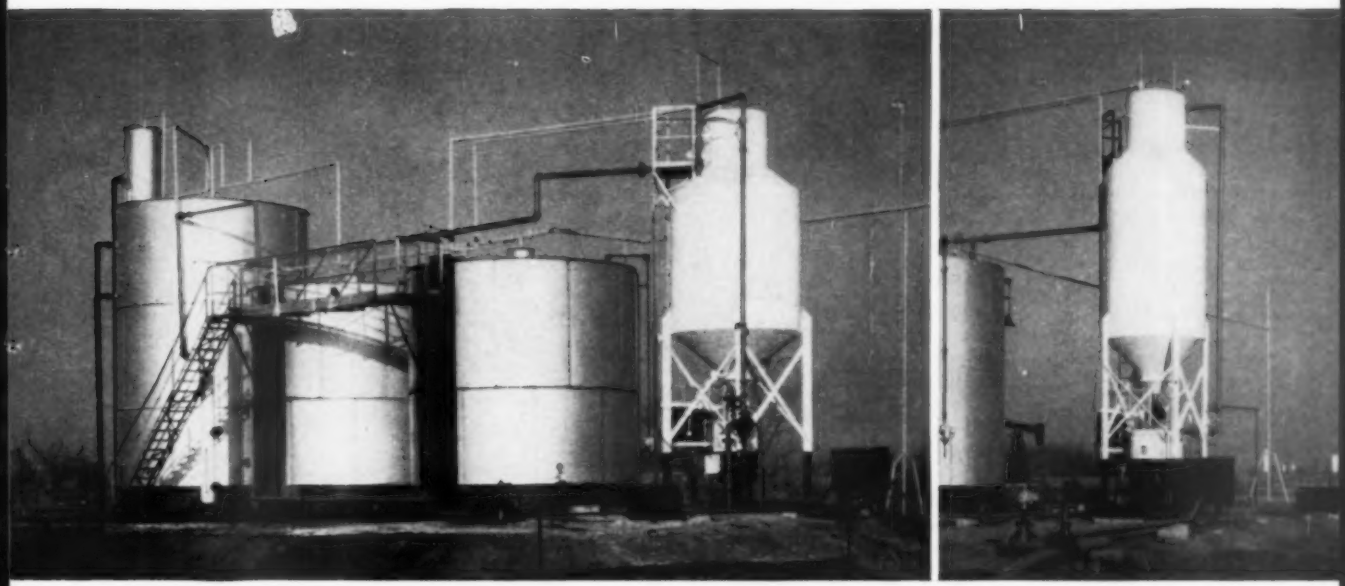
Because of the location and nature of the job, Coastal keeps a mechanic-welder on the rig, in addition to the regular crew.

Despite the rather remote location of the field, the men have been able to find housing within commuting distance and work regular eight-hour, seven-day tours. In fact, some of the roughnecks have filed on homestead claims.

Coastal is using a 1250-hp diesel rig with a 142-ft mast, capable of drilling

AUTOMATIC CUSTODY TRANSFER is now an accepted means of reducing well-to-pipeline transfer costs. Graver widens the application to smaller operations by announcing a new portable integrated production system. This now mobile unit has the significant advantages of having major controls operated pneumatically and of utilizing standard valves, pumps and auxiliaries. A full scale unit will be shown in operation at Graver's Booth 74 and 75 in the Kansas Building at the International Petroleum Exposition in Tulsa, May 14-23, 1959.

A NEW SMALL INTEGRATED PRODUCTION SYSTEM



LARGE ACT INSTALLATIONS, like those illustrated here, have been engineered and produced by Graver since their participation in the first commercial ACT unit a few years ago. The principles embodied in the new small unit are thoroughly proved by Graver's pioneering experience and by actual field performance of the first test unit. Be sure to see the new unit in operation at the I.P.E.

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to 14,000 ft with 4½-in. drill pipe. Two quads and a twin furnish power for the drawworks, rotary and main mud pump. The addition to a 500 hp main pump, the rig has a 7 by 20-in. auxiliary pump on standby. A standard boiler steam-heating system is used to winterize the rig.

Drilling Program

The drilling program is still in the experimental stage but the procedure has been outlined.

The well is spudded and a few feet of 20-in. conductor pipe is cemented in place. At 3000 ft, 13⅜-in. surface string is run and cemented to surface. While waiting on cement, blowout preventers, consisting of double rams topped by a hydraulic bag packer type unit, are installed.

An 11-in. bit is used to drill out from under the surface casing, dropping down to a 10⅝-in. hole between 4000 and 5000 ft. The 10⅝-in. hole is carried to core point at the top of the formation.

The pay zone, at about 11,000 ft, is cored with 8⅞-in. bits and then reamed to 9 in.

Jet bits are used to a depth of 6000 to 7000 ft and then conventional rock bits drill the hole to core point. A string of 4½-in., full hole drill pipe with 8 to 10 drill collars (7⅝-in. OD) is used. The bit weight ranges from 30,000 to 40,000 lb.

Mud System

A basic mud of gel, tannex, quebracho and some caustic is used. A mud weight of 75 lb per cu ft is used to 7000 or 8000 ft and then gradually built up to 95 lb. Initially the mud has a pH of about 8, a viscosity of 50 to 60, and a filter loss of 10 to 12 cc. The filter loss is cut to 3 to 4 cc for coring and the viscosity goes up to 60 to 80.

Mud pressure is 1400 to 1500 psi for jet drilling. The volume is 600 gal per min, dropping down to about 450 gal per min as the hole deepens.

Following this program, the wells are drilled to 11,000 ft in some 60 days, using from 60 to 65 bits.

Formation Difficulties

Formation troubles to look out for are lost circulation, hole enlargement by washing-out, and some high water heads in deeper formations. But all as comparatively minor problems, officials say.

Lost circulation trouble is usually cured with fiber and sawdust and cementing is often necessary. The surface casing has been set at deeper depths, from 1500 to 3000 ft, to reduce hazards of lost circulation. High-pressure water zones can be handled by

Cementing truck stands by at the Coastal rig on location for the Halasko-King offset to Standard-Richfield's No. 2 Swanson River well. A limited amount of cementing, logging and other service equipment is now available in Alaska, but the operator must make arrangements in advance to be sure of obtaining them when needed.

Unusual "tank battery" furnished storage for production tests on the Swanson River discovery well. These tests are being conducted to determine the economics of installing permanent production facilities.

Mud supplies and other perishables are stacked on pallets and wrapped in vinyl plastic at the No. 4 well, waiting to be used. Behind the stacked material are three trailers used for offices and temporary housing. At left is a corner of the corrugated-iron enclosed rig. The No. 4 was plugged about April 1 at a depth of 12,582 ft.

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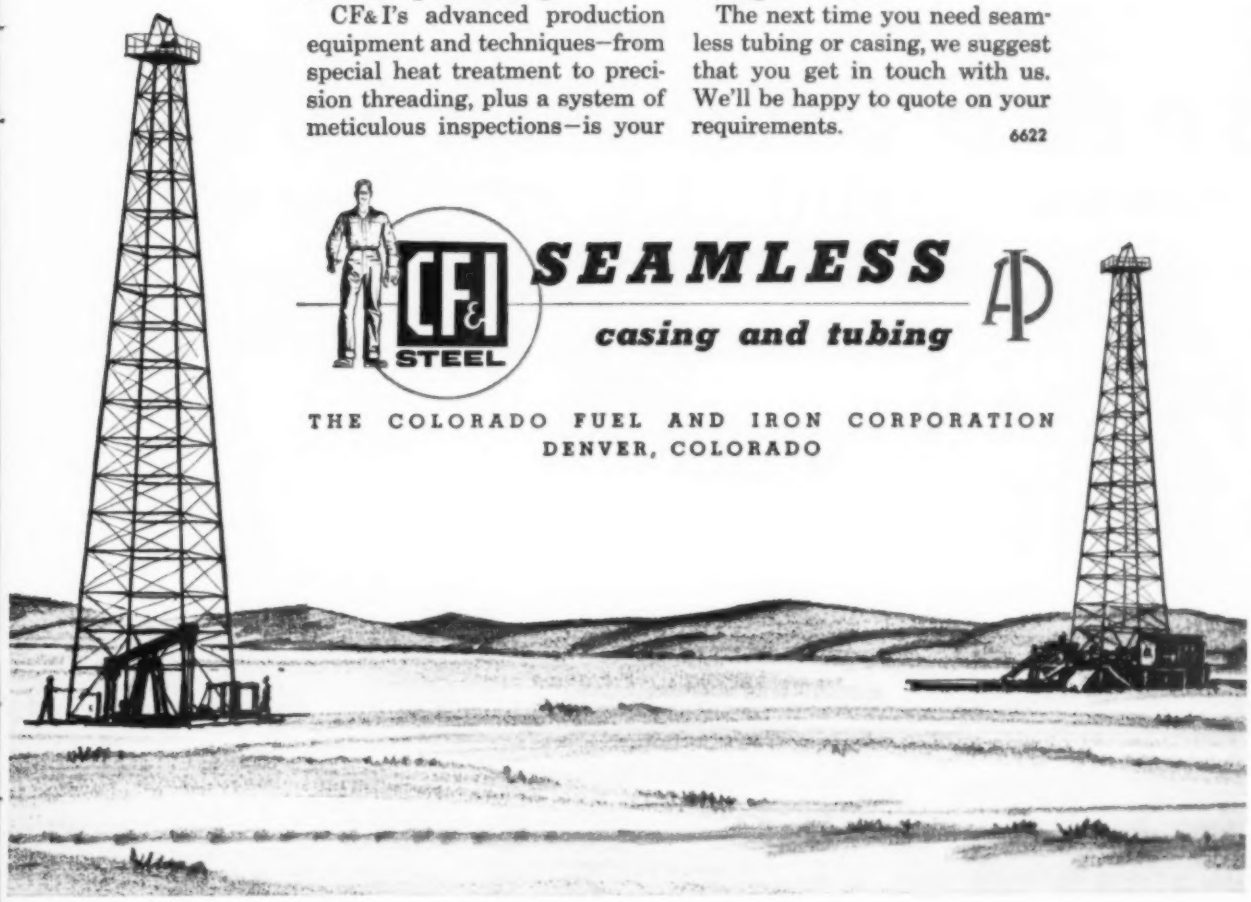

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increasing mud weight to approximately 95 lb per cu ft. Formation water is fresh and is not a problem in creating mud contamination.

Well Costs

Although the work has been relatively trouble-free, the wells are not cheap. The ones drilled to date have cost from $600,000 to $900,000 each.

For completing the wells, 7-in. casing is set through the production zone and perforated. A production string of 2½ in. tubing is run above a packer on the zone. Mud is displaced with water and the well swabbed in, if necessary.

Thirty gravity oil has a gas-oil ratio of 150-1 and is relatively clean, indicating no major production problems.

Pipeline?

Present plans call for 30-day production tests for all completed wells. Oil is trucked to Seward and shipped to California. Studies are now underway to determine the best deep water terminal for a pipeline to be built when (or if) indicated production of shut-in wells reaches 6000 bbl per day.

Defining Field Limits

Any hopes of reaching this goal quickly were dimmed somewhat when No. 3 and No. 4 proved to be dry. This was especially disappointing as the No. 3 well formed one point of a rough triangle with wells No. 1 and No. 2 at the other points. The No. 4 well now abandoned at 12,582 ft, and the Halasko-King Oil Company well, also drilling to test the Hemlock zone some 3½ miles southwest of No. 2, is helping a great deal in defining the field magnitude.

Standard's supply yard is located at the No. 2 well. The wellhead can be seen in the center of the picture with a production man working in front of it. Part of the stock of pipe and casing is shown at left. Top of one of two storage tanks appears in the foreground and, just beyond, the temporary loading rack for trucks hauling oil to Seward.

Road Construction

Aside from drilling, a major problem has been road building. It was necessary for Richfield to build a 22-mile road through muskeg and heavily wooded country before the initial drilling operations could be undertaken. Winter construction has proved more economical than summer. * * *

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55	4½" to 10¾"	500 to 15,000 ft. lbs.
57	4½" to 10¾"	300 to 8,000 ft. lbs.
58	1½" to 5½"	300 to 4,000 ft. lbs.

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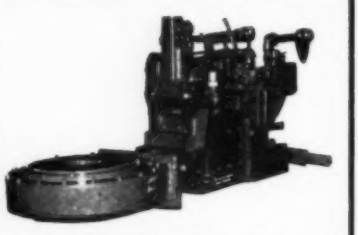

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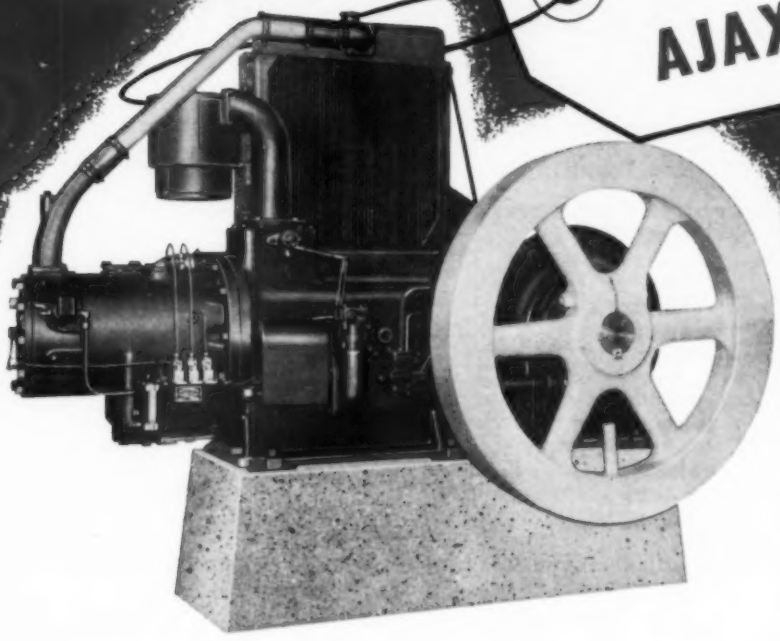

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Use of microlaterolog provides . . .

Improved Accuracy in Porosity Determination

Proper analysis and evaluation of the information available from the microlaterolog give better formation factor and porosity determinations

Albert A. Brown
The California Standard Company
Calgary, Alberta, Canada

A DEVICE FOR MEASURING borehole-wall resistivity known as the microlaterolog,[1] a focused-current logging instrument, was first introduced in 1952. It has since proved to be more accurate than the earlier microlog for determining formation factor and porosity[2] and is now widely used as a formation evaluation tool.

The microlaterolog determines formation factor and porosity of a reservoir rock from resistivity measurement of the flushed zone surrounding the borehole (R_{xo}). The formation factor (F) of the invaded rock is calculated using the following relationship[3]:

$$F = \frac{R_{xo}}{R_{mf}} \times S_{xo}^{2}$$

where

R_{mf} is mud filtrate resistivity
S_{xo} is water saturation of flushed zone

Porosity (ϕ) is then estimated from the formation factor, frequently with the use of nomograms which provide a graphical solution of the "Humble formula"[4]:

$$\phi = 0.80F^{-0.46}$$

or the "Archie" relationship:

$$\phi = F^{-1/m},\ 1.4 < m < 2.6$$

Although the microlaterolog has proved to be a very useful logging tool, under some logging conditions it has not given consistent or accurate results. The principal sources of error in determining formation factor and porosity of non-argillaceous rocks with the microlaterolog are:

1. Thick mud-cake causing the logging current to be dissipated before it enters the formation.
2. Incomplete flushing of the invaded zone surrounding the borehole.
3. Uncertainty as to the proper relationship between formation factor and porosity. The Humble formula is based on a few measurements of porosity and formation factor, mostly of sandstones with medium to high porosity; it is not always suitable for use with carbonates or low porosity

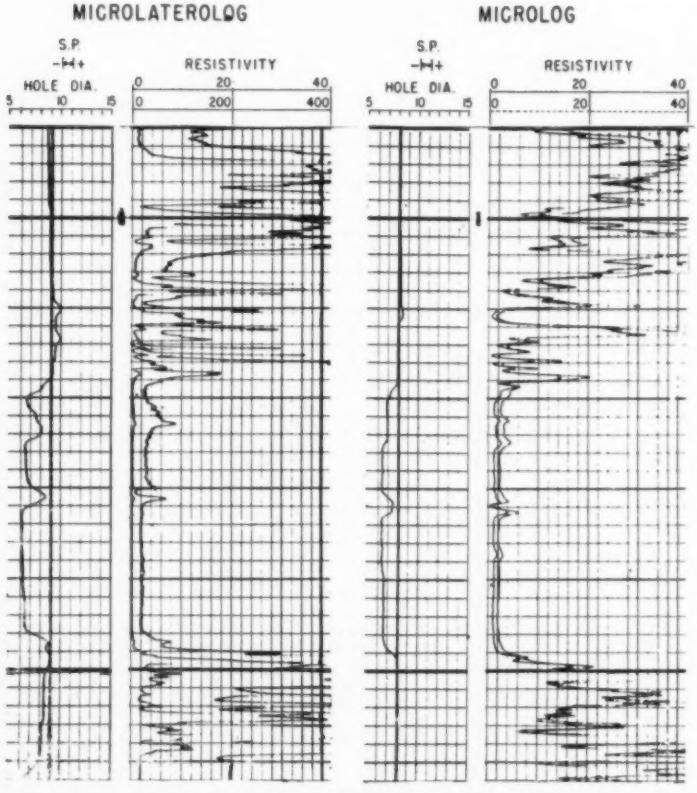

FIG. 1. **Comparison of mud-cake thickness** as determined by the microlaterolog and the microlog. The microlaterolog was run 24 hr after mud circulation was stopped; the microlog was run 8 hr after circulation was stopped.

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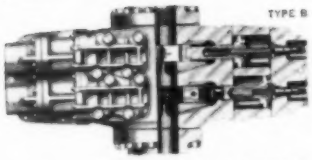
for the

LATEST ADVANCEMENTS IN BLOWOUT PREVENTERS!

WHERE ▶ *International Petroleum Exposition at Tulsa*
Oklahoma Building, Booths 1, 2, 76 and 135
(Both sides of the aisle – West end of the building)

At the 1959 Tulsa Oil Show you'll find the really important advancements in blowout prevention equipment concentrated in one big exhibit featuring Shaffer products. The equipment highlighted here is typical of what you'll see!



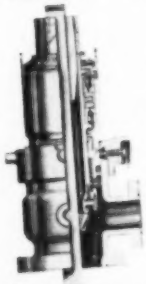
SHAFFER TYPE B and TYPE E BLOWOUT PREVENTERS

...the hydraulic control gates that offer many unequalled advantages for most drilling operations. Type B has *non-rising* locking shafts for installations where maximum compactness is desired... Type E has *rising* locking shafts for installations where quick indication of ram position is desired.

- **Both types feature the convenience of "Swinging Side-Opening" doors for easy ram changes without loss of operating fluid... and positive "In-Line", ram and piston design that eliminates yokes, levers and other complicated assemblies!**

These and many other Shaffer advancements make Type B and Type E Hydraulic Gates ideal for the great majority of drilling operations!

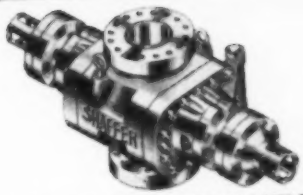
SHAFFER ROTATING BLOWOUT PREVENTERS AND STRIPPERS



...the blowout preventers that maintain continuous pressure control *automatically* as long as the drill string is in the hole. A self-adjusting Stripper Rubber automatically expands and contracts to fit the varying diameters of drill pipe, couplings and tool joints, as well as the varying shapes of square, hexagon and octagon kellys.

- **There's nothing to remember – or forget – with this unit because it is always packed off around the drill string as long as the drill string is in the hole, whether the string is rotating, being raised or lowered, or is stationary!**

Shaffer Rotating Blowout Preventers and Strippers are ideal for regular drilling, for drilling under pressure and for drilling with air or gas instead of mud. Get full details on these applications at the Tulsa Oil Show!



SHAFFER TYPE XHP BLOWOUT PREVENTERS

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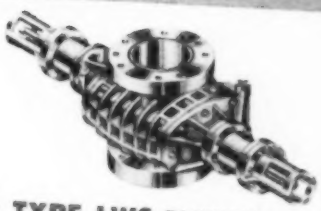
- **XHP Preventers are the simplest of all Extra High Pressure units – are easy to install, easy to operate. They feature "In-Line" ram and piston design with no levers, yokes or other complicated connections between piston and ram!**
- **XHP Preventers are also very easy to service. Their "Swinging End-Opening" design assures quick, simple ram changes without loss of operating fluid and without need for breaking any hydraulic connections!**

These and many other advancements place XHP Preventers far ahead in protection against Extra High Pressures!



SHAFFER TYPE LWS BLOWOUT PREVENTERS

...the hydraulic control gates that bring modern pressure protection to entirely new applications. Light in weight and easy to install, Type LWS Preventers are ideal for quick "in-and-out" production and re-work jobs where minimum rig-up time is a vital factor.

- **LWS Preventers can be opened or closed in 15 to 20 seconds, using a Shaffer portable hand pump that eliminates need for the usual hydraulic piping and accessory equipment. If preferred, LWS Gates can be opened and closed in as little as 2 to 7 seconds with a choice of hydraulic power units.**
- **LWS Preventers have all the latest Shaffer design features..."Swinging End-Opening" doors for maximum speed in making ram changes ...positive "In-Line" ram and piston design that eliminates yokes, levers and other complicated parts ...and many other exclusive Shaffer advancements.**

For unequalled portability in control gates, be sure to see Type LWS Preventers!

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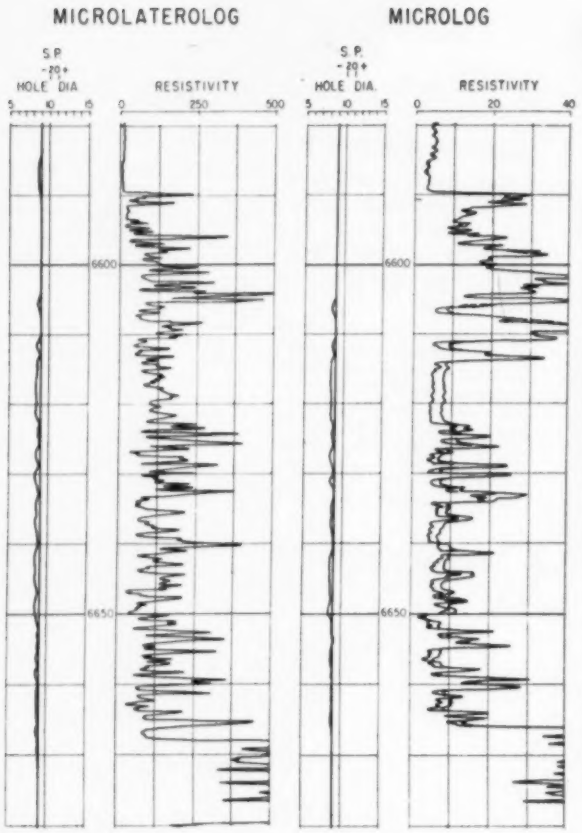


FIG. 2. **Another comparison of mud-cake thickness** as recorded by the microlaterolog, run 6 hr after mud-circulation was stopped, and the microlog, run 10 hr after circulation was stopped.

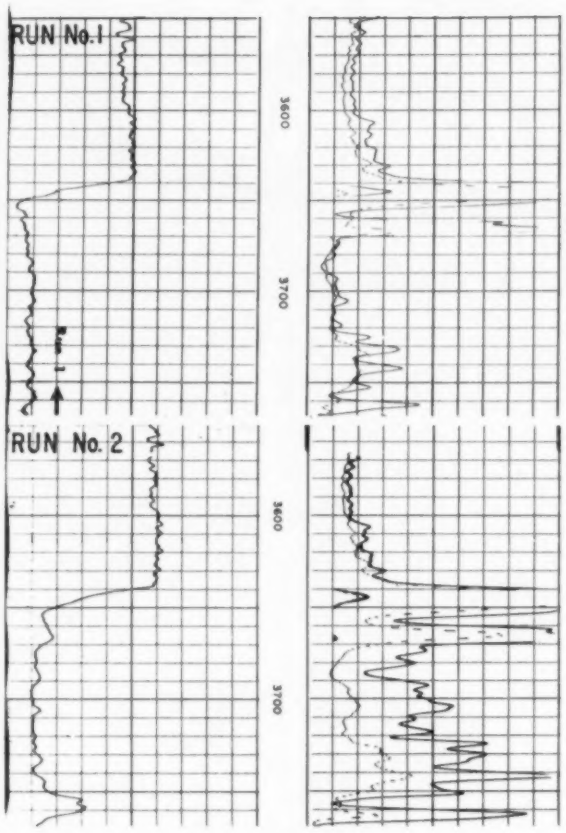


FIG. 3. **Two overlapped runs of an electrical log** run through a water-saturated formation. Run No. 1 shows that invasion was not more than 1 or 2 in. deep. Run No. 2, made 5 days later, shows invasion increased to 15 to 18 in.

sandstones. The accuracy obtainable using the Archie relationship is limited by uncertainty about the correct value of "m" to be used for a particular reservoir.

For rocks with an argillaceous matrix, the microlaterolog can be used to measure an "apparent formation factor (F_a)" which is useful in log interpretation. However, porosity cannot be estimated from this apparent formation factor except in local areas, using empirical relationships.

Effect of Thick Mud-Cake on Microlaterolog

Well logging service companies usually provide a caliper log with all wall resistivity logs. These caliper logs show that mud-cake thickness increases with time elapsed since the last round trip with the drilling bit.

Fig. 1 shows the logs of a well in which caliper logs were run with a microlaterolog and a microlog. The microlaterolog-caliper was not obtained until approximately 24 hours after circulation stopped. The caliper log shows that the mud-cake was by that time about 1½-in. thick. As a result, the microlaterlog is useless for quantitative log analysis since, opposite permeable intervals, it is reading principally the mud-cake resistivity.

Fig. 2 shows a microlog-caliper and a microlaterolog-caliper run through the same formation in another well. For this second well, because of bridging in the hole, it was necessary to make a round trip with a bit before the microlaterolog was run. Although the microlaterolog was not run until more than 24 hours after drilling stopped, a good microlaterolog was obtained showing thin mud-cake on the caliper log. This was partly because a better, lower water-loss mud had been used, but also because the round trip had removed the mud cake which had built up.

This suggests some remedies for log interpretation problems due to thick mud-cake. When experience in the area indicates that the microlaterolog will probably be affected by thick mud-cake, it should be run first in a series of logs. This may permit obtaining a good log before the mud-cake becomes too thick. Sometimes this is impossible, since the E-log is needed first to choose the intervals to be logged with the microlaterolog. In that case, if a good microlaterolog is essential for log analysis, it may be worthwhile to clean off the mud-cake with a bit before running it.

Effect of Shallow Invasion on Microlaterolog

Fig. 3 shows two overlapped runs of an electrical log across the Mission Canyon formation in a southeast Sas-

The Author

Albert A. Brown *obtained his M.S. in geology and mathematics from the University of New Brunswick in 1950. He joined the California Standard Company at Calgary in that year and from 1953 to 1958 was senior formation evaluation geologist. In 1955 he helped organize, and was first president of the Canadian Well Logging Society. At present, he is chief development geologist for California Standard.*

katchewan well. The interval is water-saturated. The similar, low reading on the 16-in. and 64-in. normal curves of the first run, made immediately after the formation was penetrated, show that invasion is not more than 1 or 2 in. deep. The second electrical log, made five days later, shows deeper invasion of about 15 to 18-in.

The microlaterologs which were run with the E-logs are shown in Fig. 4. Run No. 1 microlaterolog reads about the same as the 16-in. and 64-in. normal curves of the Run No. 1 E-log, indicating that it also is reading beyond the shallow invasion zone and measuring the formation resistivity rather than the invaded zone resistivity. For Run No. 2, the microlaterolog reads the resistivity of the invaded zone correctly, so that accurate formation factor and porosity determinations can be made with it.

For areas and formations where invasion proceeds slowly, as illustrated by this example, it is sometimes advantageous to run the microlaterolog as late as possible after drilling has stopped. When a series of logs are to be run, the microlaterolog should then be run last. The additional few hours may permit invasion to reach the depth of 4 to 6 in. necessary for microlaterolog use.

This delay, however, may result in thick mud-cake affecting the log quality, as has been discussed above. The optimum timing for the microlaterolog run must be chosen from a consideration of these opposing factors, based on experience in the area.

An example of shallow invasion of an oil-saturated interval, and its affect on microlaterolog interpretation, is discussed below.

Preparation of F_a/ϕ Charts for Microlaterolog Interpretation

Improved accuracy in estimating porosity (ϕ) from apparent formation factor (F_a) is possible if empirical F_a vs ϕ charts are prepared for each area or field where the microlaterolog is used. The preparation of such a chart for the Mississippian oil fields of the Virden, Manitoba area was as follows.

Fifteen wells from five producing fields in the Virden area of southwest Manitoba were used in the study. All wells produce oil from the Lodgepole formation of Mississippian age. Core analyses for the wells were plotted versus depth on a vertical scale of 1 in. = 25 ft, and compared with the microlaterologs; when necessary, the plots were adjusted for depth to fit the microlaterolog over the same section.

The apparent formation factor was calculated from the microlaterologs for approximately 500 points within the producing intervals of the several wells, and these points were tabulated along with the core analysis porosities for the same interval.

"Best fit" equations for the resulting data points were calculated, using an electronic computer, and assuming a relationship between apparent formation factor and porosity of the form:

$$F_a = a\,\phi^{-m}$$

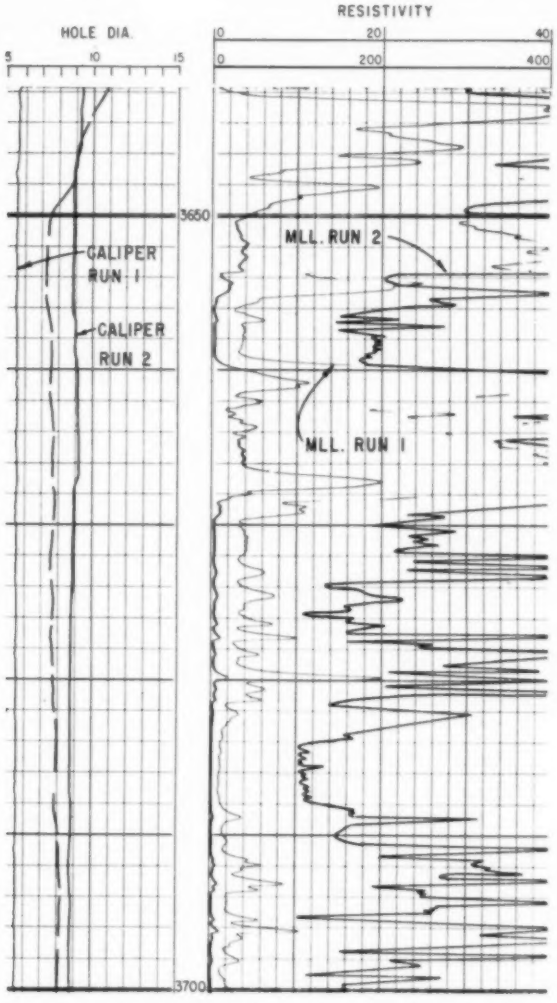


FIG. 4. **Superimposed microlaterologs** run with the logs shown in Fig. 3. Microlaterolog Run No. 2 reads the resistivity of the invaded zone correctly, so that accurate formation factor and porosity determinations can be made with it.

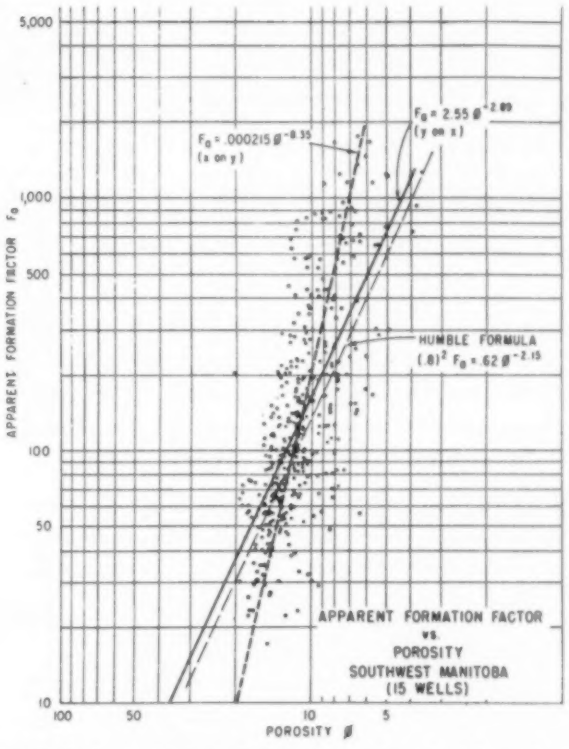


FIG. 5. **Apparent formation factor** as determined from microlaterologs is plotted on log-log paper against porosity. A "least" squares" method of curve-fitting was used to establish the "best-fit" F_a lines. The commonly used Humble formula is plotted on the graph for comparison.

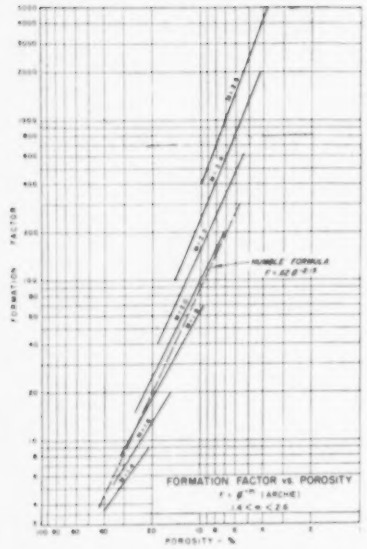


FIG. 6. **Plot of formation factor** against porosity is based on the Archie relationship formula, $F = \Phi^{-m}$, for values of m from 1.4 to 2.6. The Humble formula is also plotted on the graph.

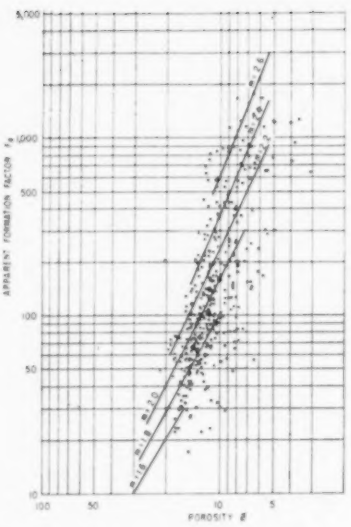


FIG. 7. **Data points from Fig 5,** with a 20 percent residual oil correction of F_a to F, superimposed on the Archie curves from Fig. 6, showing close agreement between plotted points and curves.

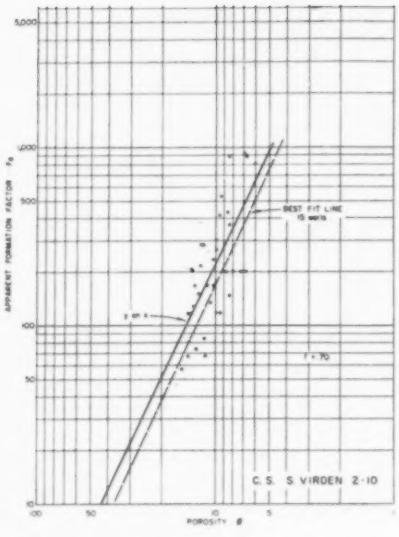


FIG. 8. **Best-fit line (y on x)** for 1 of 15 wells is parallel to, but displaced from, the best-fit line for all 15 wells. This is possibly due to an error in the measurement of R_{mf}.

A "least squares" method of curve-fitting was used. (This method assumes that the best-fit line for a group of points is the one for which the sum of the squares of either the vertical or horizontal distances of the points from the line is a minimum. If the vertical deviations are minimized the best-fit line is called the Y-on-X best-fit line; similarly, when the horizontal distances are minimized the best-fit line is called the X-on-Y best-fit line.)

The data points, plotted on log-log paper, are illustrated by Fig. 5. The calculated Y-on-X and X-on-Y lines are also shown. The correlation coefficient (r) for the data is 0.68. (The correlation coefficient is a measure of how closely the points fall along a straight line. A value of $r = 1$ indicates all points fall on the best-fit line; for $r = 0$, the points have no preferred orientation.)

An infinite number of best-fit lines exists between the Y-on-X and X-on-Y lines shown on Fig. 5. The preferred best-fit relationship between apparent formation factor and porosity depends on the type and range of errors in the F_a and ϕ measurements. If it is assumed that the core analysis measurements are accurate, and that the correct core analysis interval has been assigned to each calculated F_a value, the Y-on-X line represents the best equation for the Virden area for estimating porosity from microlaterolog measurements of apparent formation factor. However, these assumptions cannot be safely made, as will be shown, and the preferred apparent formation factor/porosity relationship lies between the Y-on-X and X-on-Y lines which are illustrated.

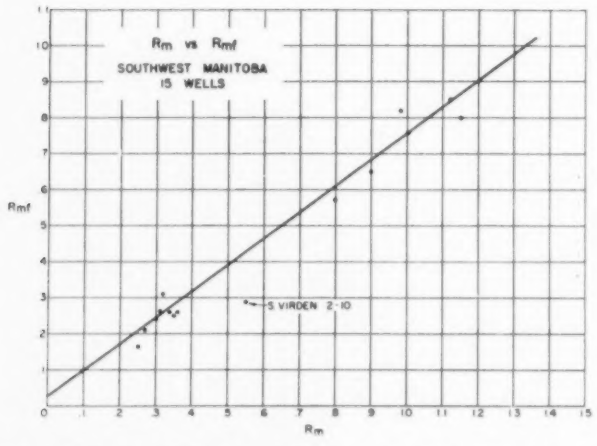


FIG. 9. **Plot of mud-filtrate resistivit** against mud resistivity for 15 wells in the study shows the plotted point corresponding to the well illustrated in Fig. 8 (S. Virden 2-10). The R_{mf} value is anomalous in that it is about one-half the R_m value, whereas an R_{mf}/R_m ratio of about 0.8 is expected for muds used in the area.

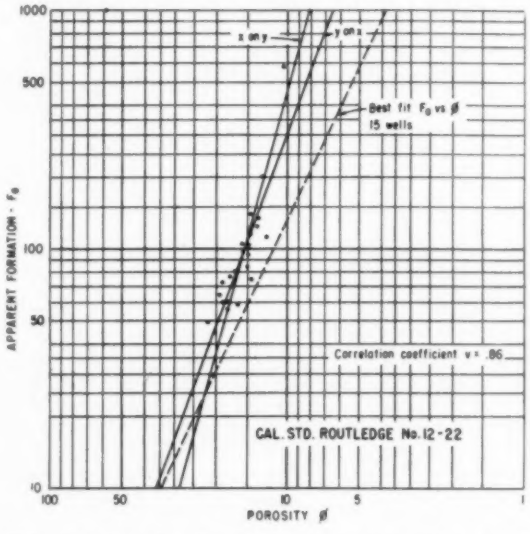
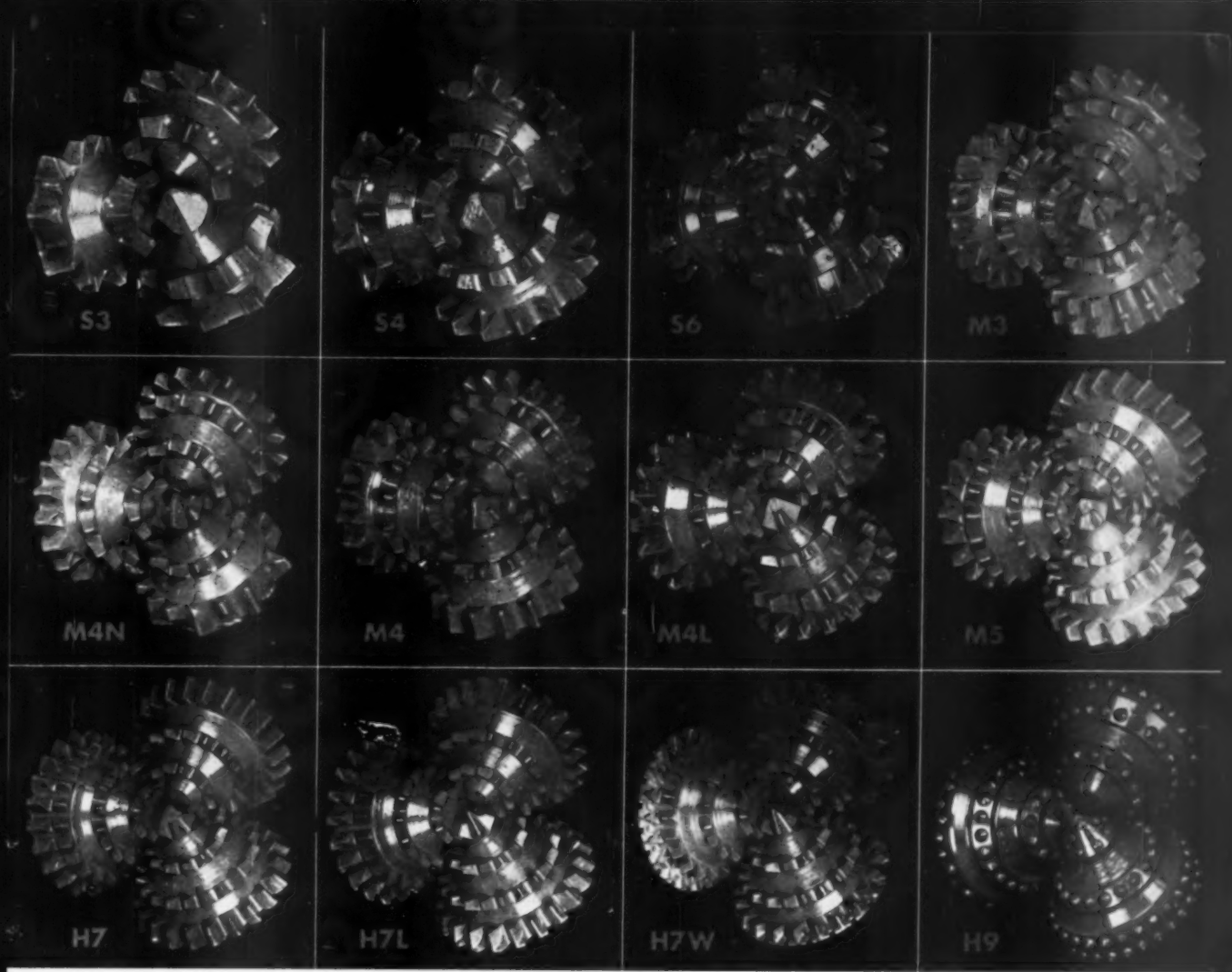


FIG. 10. **Data points for one well** show little scatter, but all fall above the 15-well best-fit line. High microlaterolog readings in the oil zone are believed to be due to shallow invasion, resulting in high residual oil saturation in the flushed zone.



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The commonly used Humble formula is plotted on the graph for comparison with the calculated best-fit lines. Residual oil saturation of 20 percent in the invaded zone was assumed in positioning the Humble formula line; this value was obtained from core studies. Use of the Humble formula in the Virden area causes a systematic error in porosity estimation from formation factor measurements.

Fig. 6 shows a F vs ϕ chart which has been successfully used by the California Standard Company in Canada. This chart uses the Archie relationship ($F = \phi^{-m}$), and indicates the range of "m" values which should be used for each formation factor value. Fig. 7 shows the data points of Fig. 5, with a 20 percent residual oil correction of F_a to F, superimposed on the Calstan porosity chart. The chart agrees reasonably well with the data points except for the lowest apparent formation factor values. The anomalous points may represent rocks which are slightly argillaceous.

Best-fit F_a vs ϕ equations were calculated also for each of the 15 wells used in the study. A comparison of the best-fit lines for each well with the average best-fit lines for all wells shows some of the reasons for scatter of the data points.

For example, the best-fit line for the F_a/ϕ points from California Standard South Virden No. 2-10 is parallel to, but displaced from, the best-fit line for all 15 wells (Fig. 8). A study of the possible reasons suggested that this is due to an inaccurate R_{mf} measurement. Fig. 9 shows that the R_{mf} value recorded for South Virden No. 2-10 is anomalous in that it is about one half the R_m value, where as an R_{mf}/R_m ratio of about 0.8 is expected for muds used in the area.

For the Calstan Routledge No. 12-22 well, the F_a/ϕ data points show little scatter, but all fall above the 15 well best-fit lines (Fig. 10). When the microlaterolog is compared with the core analysis it can be seen that the microlaterolog reads high over the producing interval but agrees with the core analysis in the interval below 2088 ft which is water-saturated (Fig. 11). (Points from this lower interval are not used in construction of Fig. 9, since this study was restricted to oil-producing intervals.) The high microlaterolog readings in the oil zone are believed to be due to shallow invasion, resulting in high residual oil saturation in the flushed zone. Study of electrical logs has shown that invasion only a few inches deep is not uncommon in the Virden area.

Fig. 12 is an example of a well for which the F_a/ϕ plot exhibits an unusually high degree of scattering. A comparison of the porosity plot with the microlaterolog suggested that this is due to a core being mislabelled as to depth, or inverted in the core box, since the porosity plot could not be fitted to the log over part of the cored interval.

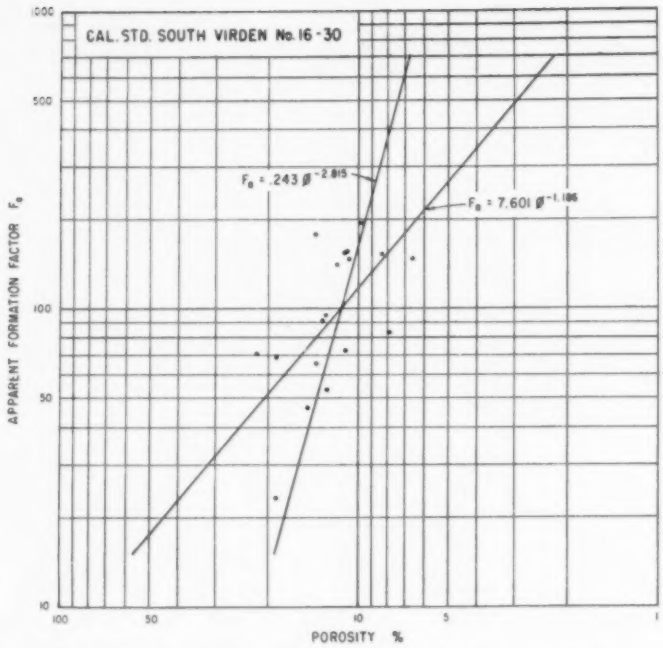

FIG. 11. **Example of a well** for which the F_a/Φ plot exhibits an unusually high degree of scattering. Comparison of the plot with the microlaterolog suggested that this is due to a core being mislabeled as to depth, or inverted in the core box, since the porosity plot could not be fitted to the log over part of the cored interval.

Knowledge of these potential sources of log interpretation errors suggests steps to guard against their future occurrence.

Summary

Accuracy in porosity determination from the microlaterolog can be improved in two ways:

1. The timing of the microlaterolog run should be chosen, using past experience in the area, to ensure that sufficient invasion is present over intervals of interest, but that mud-cake is not too thick. The optimum time to run the log will depend on several factors. For example, in Canadian areas where gyp-base mud is used, it is usually advantageous to run the microlaterolog as late as possible. There is little or no mud-cake with gyp-base muds, and invasion is shallow because of the low water-loss properties of the mud.

2. For field areas, empirical F_a/ϕ charts should be constructed. These charts give increased accuracy in porosity determination, as they average out errors due to variable residual oil saturation, changes in formation factor/-porosity relationship, effect of mud-cake, etc.

Acknowledgments

The author wishes to thank Ian Ritchie, of the California Standard Company, for assembling much of the data used, and the management of the California Standard Company for permission to publish this paper.

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2. Smith, H. D., and Blun, H. A., "Microlaterolog Versus Microlog for Formation Factor Calculations," *Geophysics*, April 1954.
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'Major Find' Reported in High BHP Area

A high pressure gas-condensate discovery which may turn out to be one of the year's major finds has been tested in Cameron Parish by Tidewater Oil Company. Their No. 2 Lacassane, four miles east of Chalkley field and five miles southwest of nearest production at South Thornwell field, has the deepest Camerina sand production ever encountered and a calculated bottom-hole pressure in excess of 14,000 psi.

Tidewater's discovery, 15 miles west of Jennings, on production test flowed at the rate of 2,600,000 cu ft of gas daily through ⅛-in. choke with 87.5 bbls of 48.2 deg condensate per million through perforations at 16,122-130 ft in the Miocene. Flowing tubing pressure was 11,300 psi. The company has more than 20,000 acres in the vicinity.

The unexpectedly high pressures encountered made the discovery of these important new reserves a costly experience for Tidewater. The first test on the large block had to be abandoned below 16,000 ft when the Kelly Joint kicked out of the hole and collapsed the drill pipe in several places. When several months of fishing operations failed to clear the hole, enough evidence was available to merit plugging the hole and skidding the rig 360 ft north for a new test.

The location of the well is deep in the Louisiana swampland and required construction of a mile and a half of new board road, a similar section of reconditioned shell road, and construction of a 105-ft bridge at a total cost of well over $100,000 before the bit could be spudded in.

All told Tidewater paid nearly $2 million to locate the new production, including a mud bill of nearly half a million.

The excessive pressures required extraordinary precautions and expenditures to find these new reserves. The blowout preventer on the second well tested safe at 15,000 psi. The casing program called for P-110 pipe beginning with the 9⅝-in. string and a final 4½-in. liner with a minimum yield of 14,420 psi. The special tubing, with a minimum yield above 25,000 psi, weighs 11.65 lb per linear ft, compared with normal tubing weight of 4.7 lb per ft.

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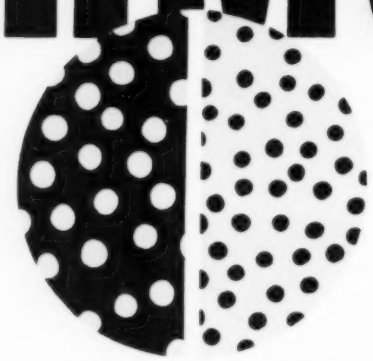

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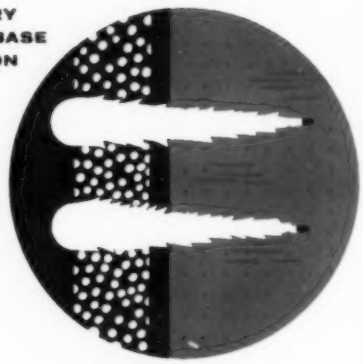

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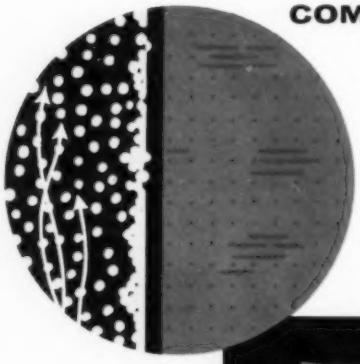

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New Look in Offshore Drilling

Designed with a working capacity of over 20,000 ft, this platform boasts a versatile blowout preventer system capable of handling any pressures encountered in its working area

David L. Black
Austin, Texas

GULF COAST DRILLING ACTIVITIES during the past year have been marked by a steady movement of drilling barges and platforms. But instead of moving to new drilling locations in the Gulf, many of the offshore units have been under tow to new assignments in foreign waters . . . and others have returned to their home berths to await a revival in Gulf Coast activity.

A relatively new platform, however, is making its presence known in the Gulf waters. Penrod Drilling Company's new way of doing things is making their offshore unit stand out in South Louisiana. The "Petrel," commissioned in 1958, has already put in an impressive amount of work. At the present time, it is drilling for Placid Oil Company in Block 118 of the Eugene Island area south of Morgan City.

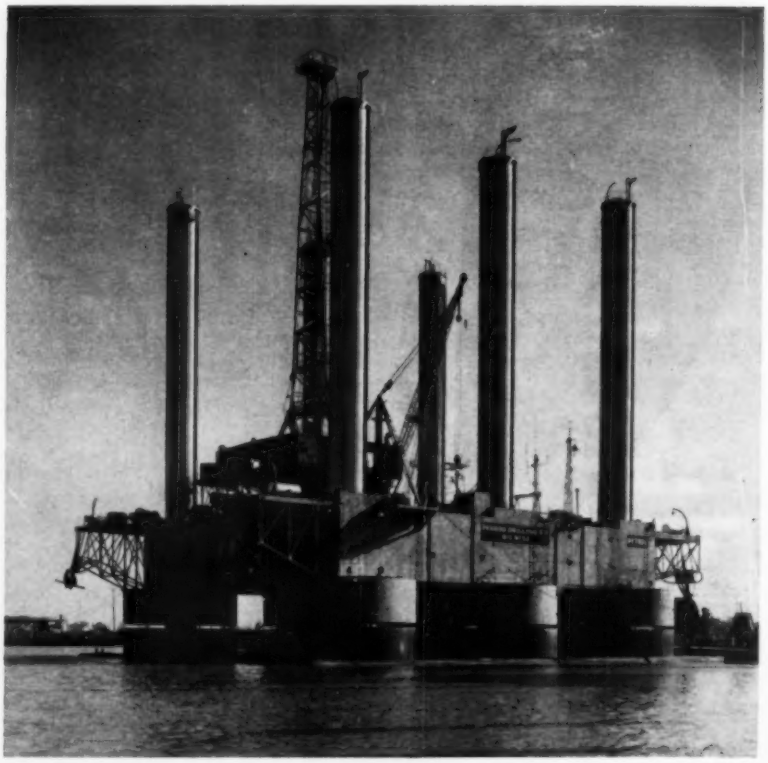

FIG. 1. **The "Petrel" ready for moving,** with its six columns jacked up and the submersible hull raised. Notice the anchors at both ends of the structure.

Platform Construction

The Petrel is one of the biggest platforms of its type in service. From the heliport to the opposite end, 250 ft of space covers the Gulf. Supported length is 196 ft, with a width from column to column of 174 ft. Six columns 180 ft in height support the upper platform above the surface of the Gulf. The platform itself rests on a submersible hull on the ocean floor. When the rig is moved, hydraulic jacks and a pumping system raise the lower section until it floats below the work unit. Then the entire unit is moved by tug to the next location.

In two of the columns, elevators carry workmen down to the level of the lower hull, where they can inspect pumps and compartments to make sure all equipment is functioning properly.

Size alone, however, is not responsible for the Petrel's reputation. Its ability to do the job properly is equally important. With five heavy diesel engines furnishing power, the rig has a working capacity of over 20,000 ft, and is presently completing holes over 16,000 ft deep.

Working on locations 25 to 80 miles from land, many materials which could be supplied in a few hours on land have to be stored in quantity on the Gulf. The mud system, for example, has a reserve capacity of 806 bbl, with an active working capacity of 583 bbl. When shipments are made from the base at Morgan City, special barges with two 1000-sack storage tanks bring bulk material to the unit. There, air hoses operating under 40 psi of air pressure are attached to the top of the bin, with large feeder lines connecting the bin to the storage units on the unit.

Air pumped in the top forces the bulk material through the hoses at the bottom to storage units on the Petrel. The same procedure is used to transfer cement to the unit.

Chemicals and other additives are the only types of sack material used on the rig, and these are unloaded by cargo nets to an arrangement of conveyor belts, where they are carried to storage centers.

Two huge pumps furnish power for the mud system. In an emergency, they can be hooked directly to the kill line to pump mud in the hole under pressure.

Levingston Shipbuilding Company of Orange, Texas, constructed the Petrel in 1958 at a cost of $8,500,000. Equipment, however, is not the only item that makes the Petrel so expensive. Its living quarters are among the best available, and its food ranks equally well with anything to be had on land.

Living Facilities

Two cooks are constantly on duty, rotating in shifts like the drilling crews. At any hour during the day or night, a crew member can get a snack or a full-course meal. A typical menu for dinner consists of roast beef, turkey, steak or jambalaya, with 12 or 15 vegetables accompanying the meat, and 3 or 4 desserts to end the meal. There's never any complaint about the quality of the food. In fact, many men grumble because they don't have equivalent fare when they go home.

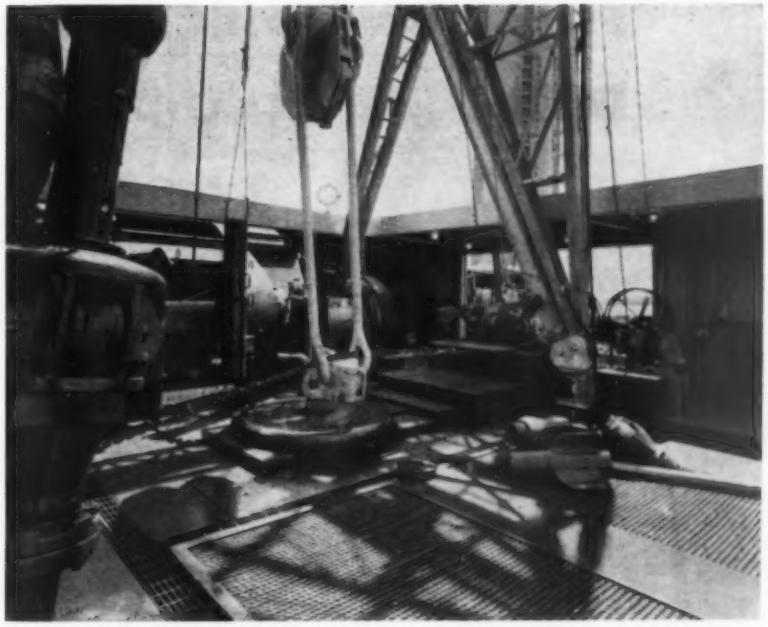

FIG. 2. **View of the rig floor,** rotary table, and drawworks. The driller's work station is behind the swivel in the foreground. Behind the supporting brace is one of the columns, with markings indicating depth of submersion.

Living accommodations on the Petrel equal hotel and motel rooms on land. The Petrel has a number of staterooms, each housing two men. Two bunks, two desks and a lavatory are in each room. Stewards provide clean sheets and towels daily. The living quarters are sound-proofed from the remainder of the rig and have complete air conditioning. Next to the dining room is a lounge for those off duty, with card tables, magazines, newspapers and a television set.

Work schedules are set up on a week-on week-off basis. Many members of the crew live in Mississippi,

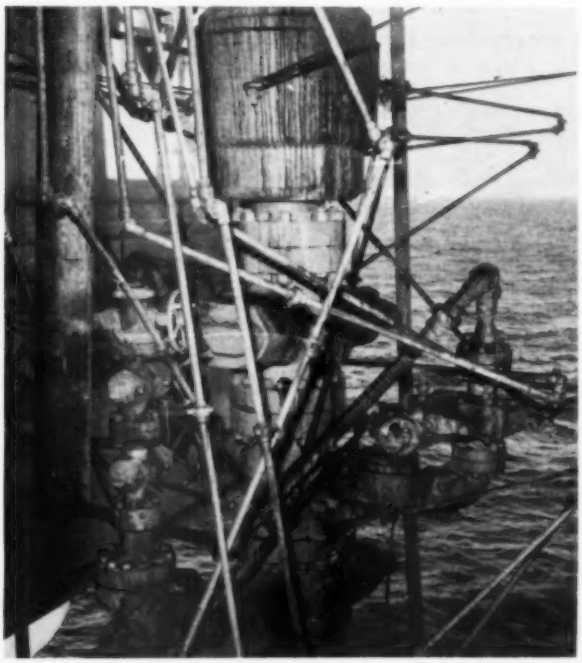

FIG. 3. **Blowout preventer stack** consists of an annular-type preventer, a single-gate preventer with blind rams, a drilling spool with two outlets, and a single-gate preventer with pipe rams. The stack is firmly secured to the platform by cables on four sides.

FIG. 4. **From the edge of the heliport,** the remote blowout-preventer controls can be seen at left-center. The open door leads to the lower deck. Casing storage is to the right.

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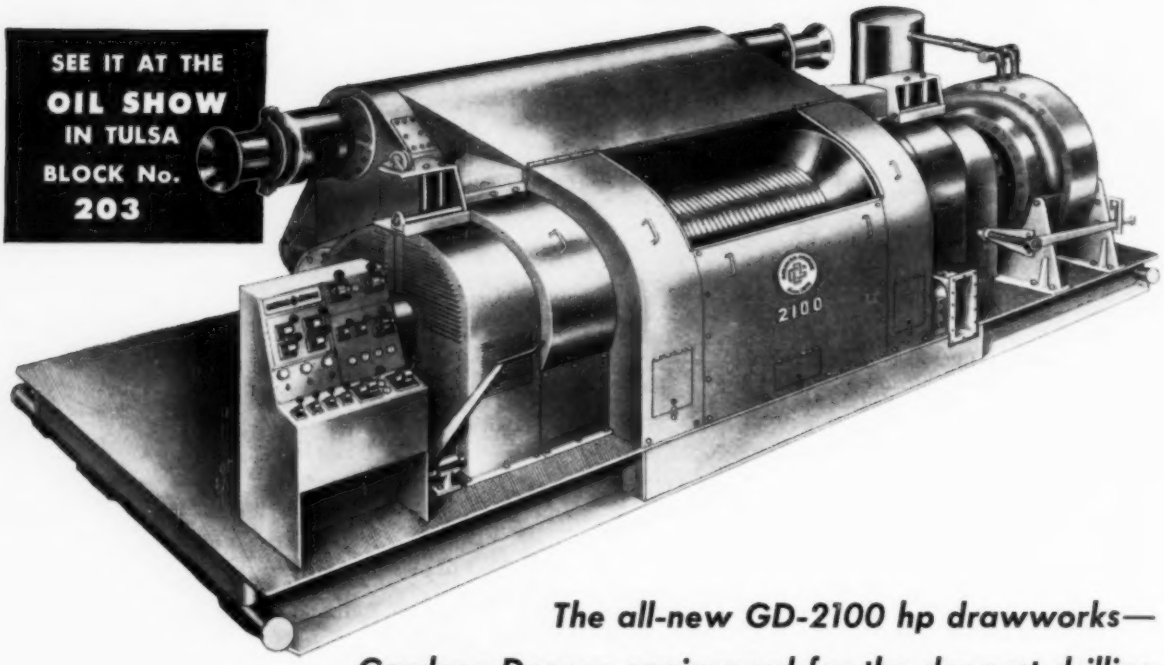

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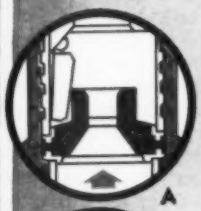
1. To eliminate the "piston-effect" of pressure surges which occur when closed-end casing is being lowered. This reduces the hazard of breaking down weaker formations.

2. To speed up the casing run by eliminating time-consuming surface fill-up of the casing. Uninterrupted lowering of the casing reduces the possibility of casing becoming stuck before reaching bottom.

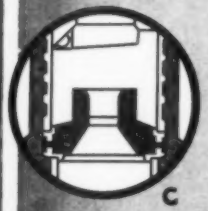


A

Circle A, a view 90° from that of the large illustration, shows the Filrite valve in running-in position. The resilient diaphragm valve remains closed until the differential fluid pressure across it overcomes its inherent resistance to open.

B

Circle B shows the rubber diaphragm inverted by pump pressure as the well is being cemented. Filrite is full opening and will allow passage of a bridging to actuate other equipment which might be installed on the casing beneath a Filrite Collar.



C

Circle C shows the spring-loaded flapper valve in closed position after being released by inversion of the diaphragm. The flapper valve in the Larkin Filrite equipment is very strong and has no depth limitations.

Available but not illustrated:

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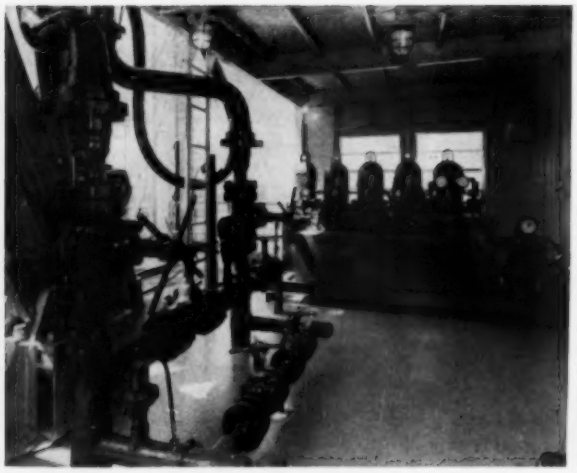

FIG. 5. **Controls for the mud system** are to the left. In the center is the hydraulic accumulator for the blowout preventers, with test apparatus to the right. This part of the rig floor is completely sheltered and easily accessible from the rig floor, seen to the left.

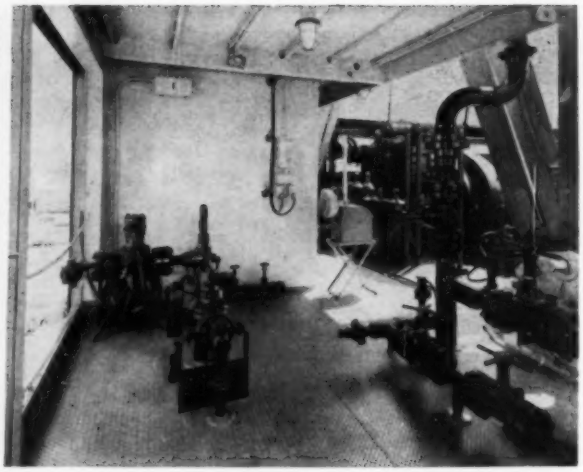

FIG. 6. **Looking from the accumulator,** the controls for the mud system are on the right, with the choke flow manifold on the left. This view shows the open union to the extreme left, with the lift-plug valve immediately ahead of it. One choke line is visible, going through the floor to the shale shaker below. The driller's work station and the drawworks are visible to the upper right.

Texas, or northern Louisiana, and drive home during their seven days off.

Crew Transportation

Although the Petrel has a heliport, crew boats are the principal means of transportation. Helicopters are used only in case of emergencies. However, the crew boats offer every convenience during the seven-hour ride to the rig. Each boat is steel, over a 100 ft long, and air conditioned completely. In the cabin, leather seats and sound-proofed walls make riding comfortable for the crew. If they prefer, they can go below to the sleeping quarters, where eight bunks are ready for anyone who wants to sleep. The boats all have well-stocked galleys, where there are ingredients for everything from a cup of coffee to a complete meal.

Once the crew arrives at the rig, they use a unique form of transportation to get from the deck of the boat to the Petrel's deck 50 ft above the water. A rope basket with a canvas bottom carries men from the boat to the unit.

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Lowered by a crane on the main deck, the basket can carry six men at a time. Each passenger has to wear a life preserver in case he falls from the basket. To the present time, however, there have been no mishaps.

Blowout Preventer System

On a rig this far from land, the blowout preventer system is one of the most important parts of the entire unit. It has to be good, for a blowout could turn a minor accident into a catastrophe. The Petrel carries a versatile hookup, capable of dealing with any pressures encountered in the area.

The following items make up the preventer stack: On top, an annular-type preventer, then a single-gate preventer equipped with blind rams, a drilling spool with two outlets, and a single-gate preventer with 5-in. pipe rams. The outlets on the spool have 4-in. seamless, Series 160 line going from the spool to the manifold on the rig floor. Two valves close and open the lines. Both lines coming from the spool are equipped with this pair of valves. The preventers have manual controls to be used in case the operating system fails. Everything on the stack except the lift-plug valves can be operated hydraulically from the derrick floor.

On the floor, the operating system controls, the controls for the mud system and the choke-flow manifold are grouped in one location. The unit is about 10 ft behind the driller's work station, where he or the toolpusher can operate the controls while watching work on the rig floor.

Controls on the accumulator, a 100-gal unit, operate the following equipment: The flow line valve, pipe ram preventer, blind rams, choke line valve and the annular-type preventer. By hooking the accumulator to the union on the kill line and closing the pipe rams and the annular preventer around a joint of pipe, the operator can put as much as 15,000 psi of pressure on the preventer stack.

To one side of the heliport, about 80 ft from the hole, Penrod has installed a remote control unit. Hooked to the accumulator, it can shut-in the hole in case of an emergency. The unit has a full set of controls identical to those on the primary accumulator.

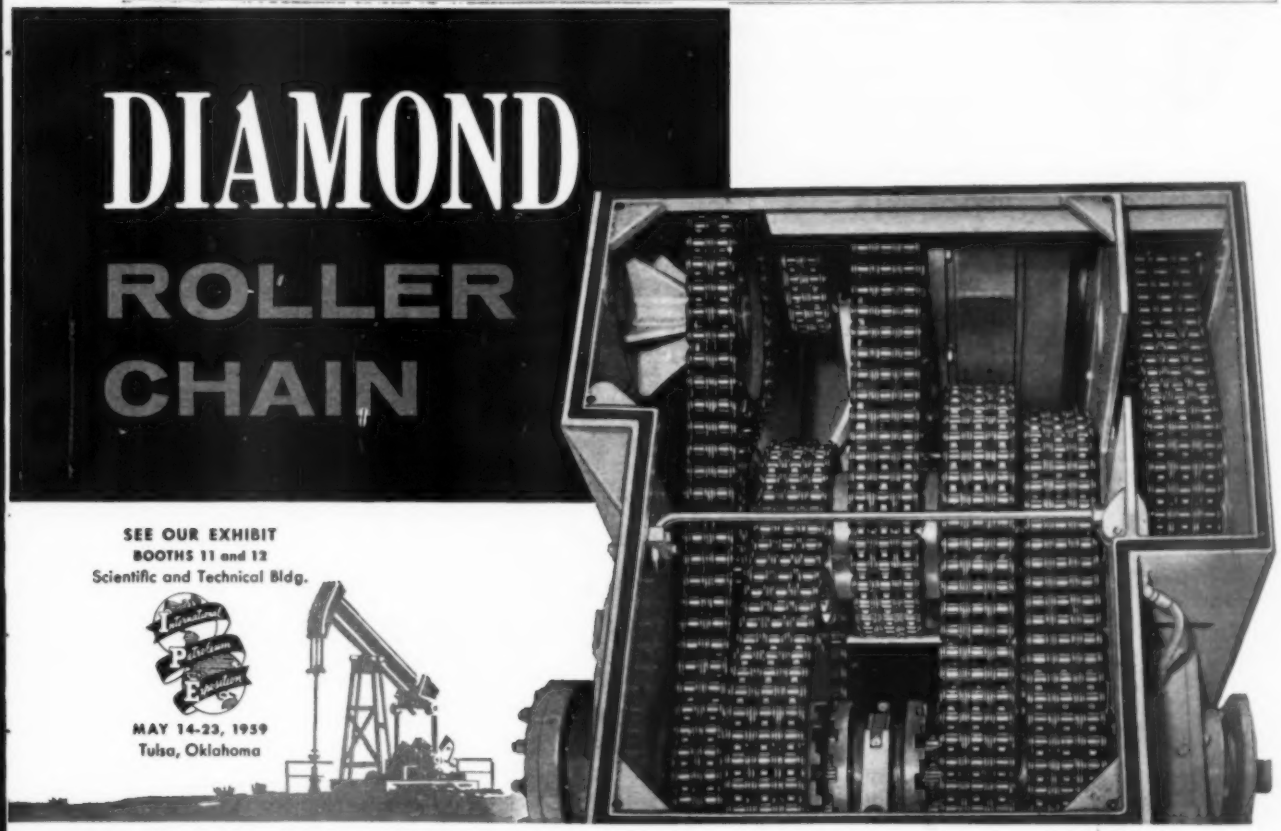
Where 15 valves were formerly needed to handle the choke-flow operations, the Petrel has a new unit with 3 valves replacing the former 15. Another feature is its location on the rig floor rather than below near the preventer stack.

The choke line leading from the drilling spool on the preventer stack enters the rig floor, where it ties into a three-way cross. Three 2-in. lines, each operated by a lift-plug valve, go to outlets. Two of the lines make a 90° bend toward the floor, and have a choke installation with positive chokes on the end. The choke lines lead directly to the shale shaker, below the manifold on the lower deck. The third line, also controlled by a lift-plug valve, ends in an open union. Flexible connections on the floor allow this line to be connected to the mud pumps, or if greater pressure is needed, to high-pressure pumps. A pressure gage mounted on top of the cross gives a constant pressure reading from the hole.

In case a straight bleed-off is necessary, the pressure-operated valve on the other side of the drilling spool can be opened, or pressure can be controlled by using a large positive choke on the manifold.

From this location, the pusher can watch action on the drilling floor, and at the same time control pressure from the hole. With the lift-plug arrangement on the choke lines, he can bleed pressure off through one line while changing the choke on the other. If the lift-plug valve should fail, he can close the pressure-operated valve near the drilling spool and replace the valve.

From many points of view — food, housing, transportation, and most important, the job done by the Petrel and its crew—offshore drilling has taken on a new look. If oil is to be found under water, men and equipment of units like Petrel will be the ones to do it. ★ ★ ★



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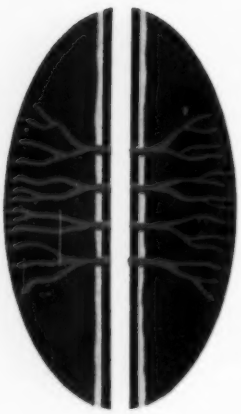

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The Reaming Cone bit, introduced in 1917 and manufactured through 1921, was the first bit to be equipped with reamers to hold the gage of the hole. However, the water courses in the bit tended to washout. To overcome this problem, Hughes developed the Simplex bit with a replaceable wash pipe. This made it possible for one bit body to outlast many sets of cones. The Simplex was also equipped with longer, more efficient reamers, that were easier to change than those on the Reaming Cone bit.

To accommodate the larger reamers and wash pipe, the Simplex body was made longer. In the larger sizes, it was a huge bit, weighing up to three tons.

The Simplex was introduced in 1921 and soon took over completely from the Reaming Cone bit, reigning supreme in the oil fields from late 1921 through the early 30's. It set new drilling records; drilled millions of feet of hole and advanced rotary drilling throughout the world.

Unit cones, introduced with the Simplex bit, made the bit easy to dress. But it was the self-cleaning unit cones, introduced in the middle 20's, that gave the Simplex its widest acceptance and gave rotary drilling its biggest boost by increasing the variety of formations the rotary could drill. The self-cleaning cones also led directly to the next dramatic rock bit development: the Unit bit—the forerunner of today's two-cone and Tri-Cone bits.

With the introduction of the Unit bit the Simplex faded into obsolescence. The Unit bit eliminated the expense of dressing bits on the rig floor and the purchase of costly bit heads and parts, greatly reducing the operator's bit investment. And it accelerated a Hughes objective that has continued through the years—reduction of drilling costs through improved bit performance.

In the painting at the left—the artist, using old photographs as a guide, has re-created a typical Mid-Continent rig floor scene in the mid-20's. On the floor at the left of the rotary is a Hughes Reaming Cone bit. Although rapidly passing from the picture, the Reaming Cone bit, in the larger sizes, was saved by operators to drill rock encountered occasionally in surface digging. Stacked to the right of the rotary are extra Simplex bits and a Disc bit, developed by Hughes as a soft formation bit before the advent of self-cleaning cones. Large reproductions of the painting, suitable for framing, are available for the asking. Write: Advertising Department, Hughes Tool Company, Box 2539, Houston.

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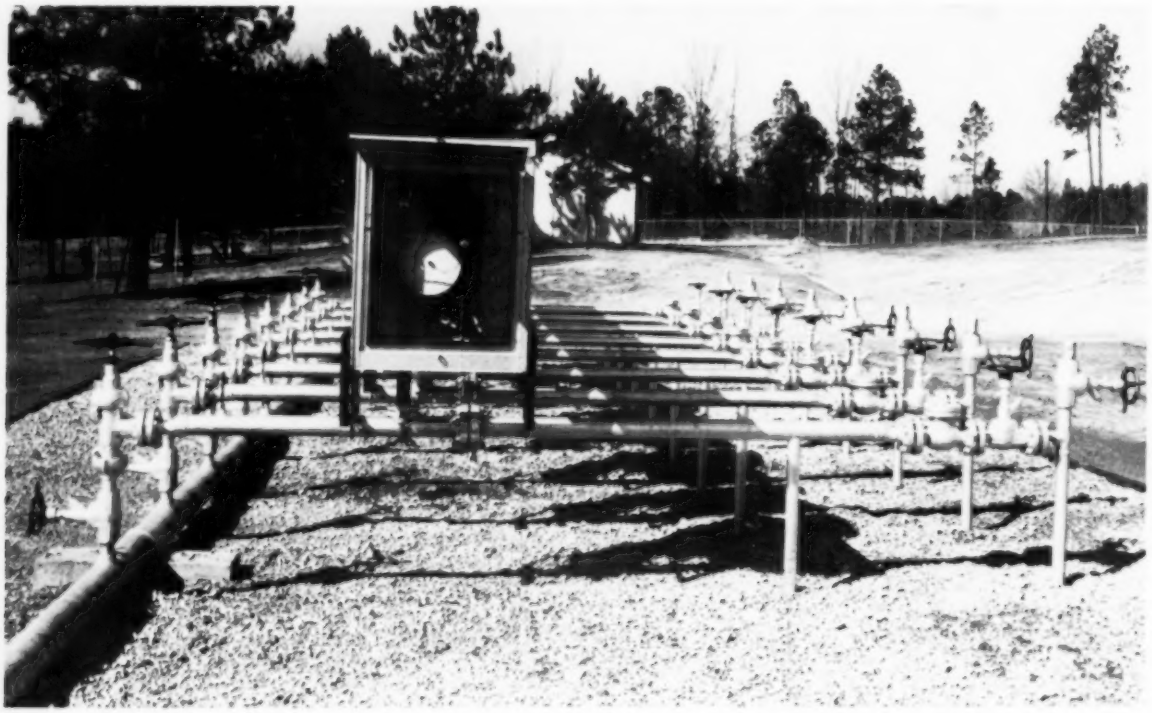

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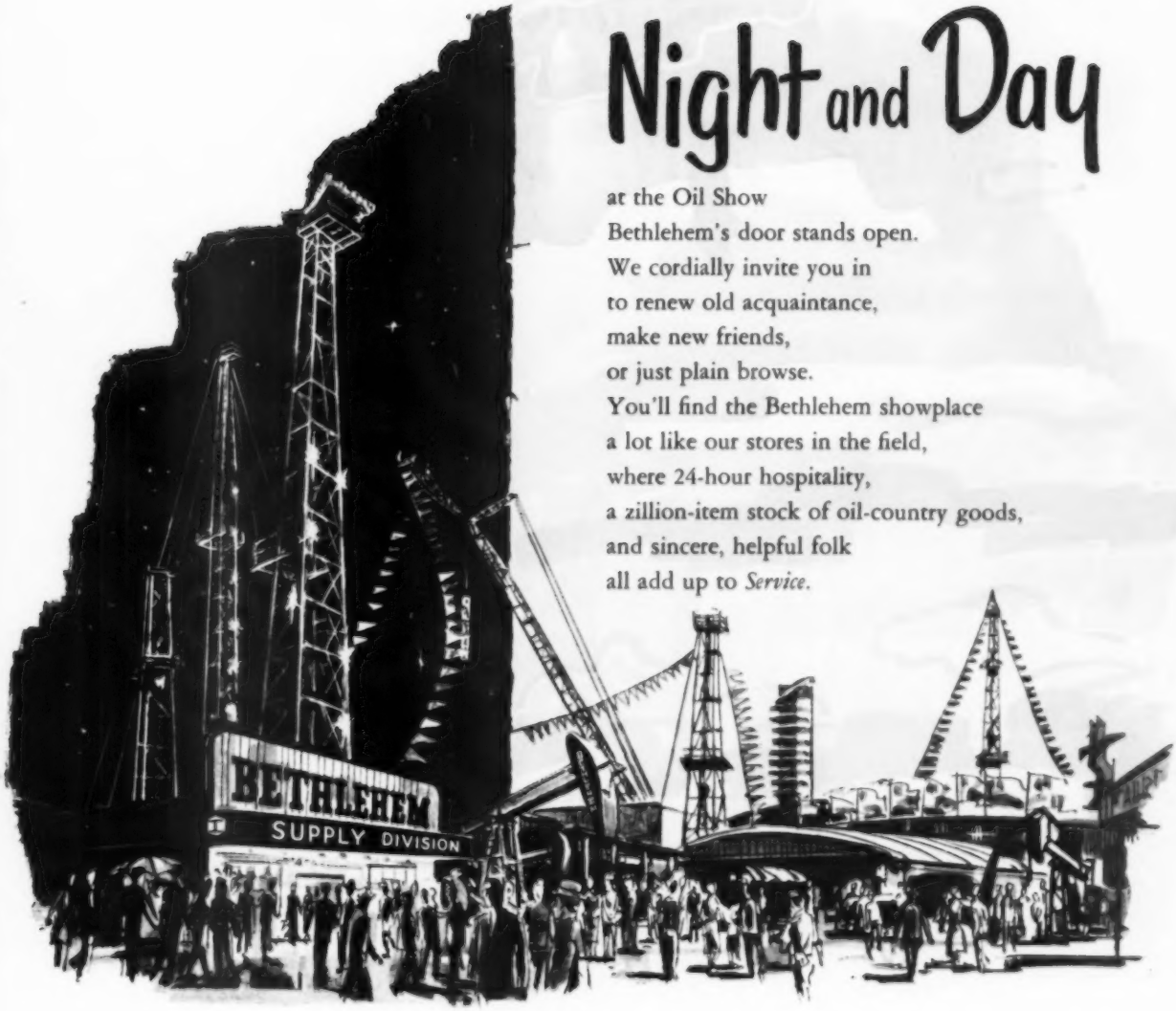

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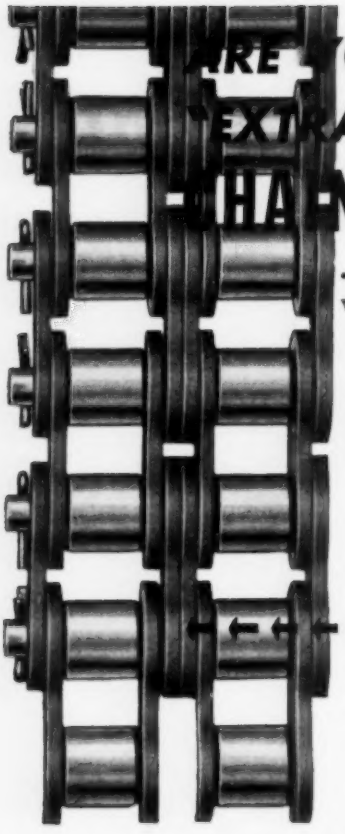

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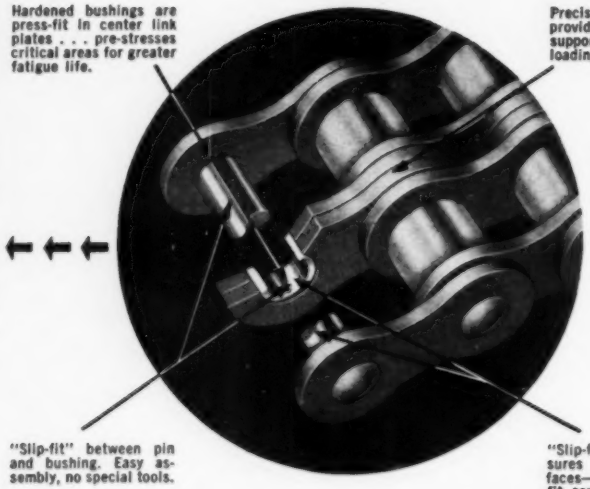
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Increasing importance of workovers warrants . . .

A New Look at Workover Fluids

As new production becomes more costly to find and develop, workover programs are receiving added attention. Proper workover fluids will protect existing producing reservoirs

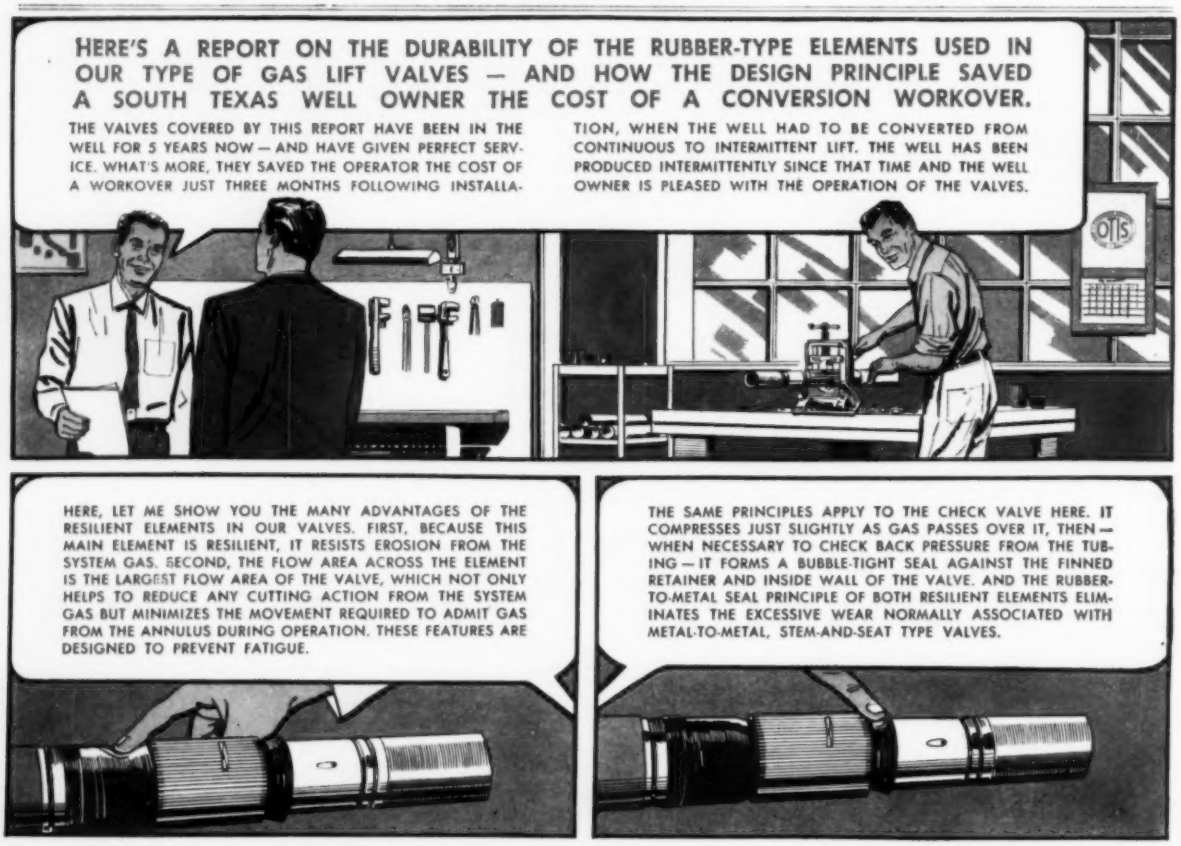
Robert W. Ruhe, Jr.
Magnet Cove Barium Corporation
Houston, Texas

WORKOVER PROGRAMS are becoming increasingly important. With new production more costly and difficult to find, many operators are wisely taking greater care to insure maximum protection to the existing producing reservoirs.

Also, workovers are becoming more important because of the outlook for new discoveries, most of which will likely be less prolific. And, they will probably be from dirty reservoirs because of the need for completing in several broken zones in shaley or silty formations. Many of the wells now being completed are in formations which would not have even been considered for completion 10 years ago. Further, completions in such formations are certain to grow in number each year.

Importance of Workovers

Workover programs and fluids are


HERE'S A REPORT ON THE DURABILITY OF THE RUBBER-TYPE ELEMENTS USED IN OUR TYPE OF GAS LIFT VALVES — AND HOW THE DESIGN PRINCIPLE SAVED A SOUTH TEXAS WELL OWNER THE COST OF A CONVERSION WORKOVER.
THE VALVES COVERED BY THIS REPORT HAVE BEEN IN THE WELL FOR 5 YEARS NOW — AND HAVE GIVEN PERFECT SERVICE. WHAT'S MORE, THEY SAVED THE OPERATOR THE COST OF A WORKOVER JUST THREE MONTHS FOLLOWING INSTALLATION, WHEN THE WELL HAD TO BE CONVERTED FROM CONTINUOUS TO INTERMITTENT LIFT. THE WELL HAS BEEN PRODUCED INTERMITTENTLY SINCE THAT TIME AND THE WELL OWNER IS PLEASED WITH THE OPERATION OF THE VALVES.
OTIS
HERE, LET ME SHOW YOU THE MANY ADVANTAGES OF THE RESILIENT ELEMENTS IN OUR VALVES. FIRST, BECAUSE THIS MAIN ELEMENT IS RESILIENT, IT RESISTS EROSION FROM THE SYSTEM GAS. SECOND, THE FLOW AREA ACROSS THE ELEMENT IS THE LARGEST FLOW AREA OF THE VALVE, WHICH NOT ONLY HELPS TO REDUCE ANY CUTTING ACTION FROM THE SYSTEM GAS BUT MINIMIZES THE MOVEMENT REQUIRED TO ADMIT GAS FROM THE ANNULUS DURING OPERATION. THESE FEATURES ARE DESIGNED TO PREVENT FATIGUE.
THE SAME PRINCIPLES APPLY TO THE CHECK VALVE HERE. IT COMPRESSES JUST SLIGHTLY AS GAS PASSES OVER IT, THEN — WHEN NECESSARY TO CHECK BACK PRESSURE FROM THE TUBING — IT FORMS A BUBBLE-TIGHT SEAL AGAINST THE FINNED RETAINER AND INSIDE WALL OF THE VALVE. AND THE RUBBER-TO-METAL SEAL PRINCIPLE OF BOTH RESILIENT ELEMENTS ELIMINATES THE EXCESSIVE WEAR NORMALLY ASSOCIATED WITH METAL-TO-METAL, STEM-AND-SEAT TYPE VALVES.

becoming more important despite the tremendous forward strides in the past few years by secondary recovery processes. These processes have not yet reached the ultimate — 100 percent recovery of the available hydrocarbons. While they do increase the recoverable oil in the reservoir, they cannot overcome damage inflicted to the reservoir during the drilling and primary recovery stages. This means that greater care must be exercised during the primary producing stage.

Under the present economic stress of high costs and low profits, some operators have attempted numerous short cuts in workover programs. They have naturally tried to reduce costs. More often than not, this has in the past led to the selection of the least expensive workover fluid.

Recently, however, in what might be termed a reversal of this attitude, many operators are taking a new and closer look at workover programs and at workover fluids. Many are finding that the more expensive and stable fluids produce results which far outweigh their extra cost. In many instances, in looking at the overall program, they are discovering that the cheaper workover fluids are not necessarily the most economical to use.

A workover is defined as any operation which tries to re-establish or increase oil or gas production from a previously drilled well. This may involve minor repairs only to well equipment or abandoning one zone and recompleting in another. Whatever the operation, most workover operations must use some kind of fluid to kill and control the well while the required operations are being performed.

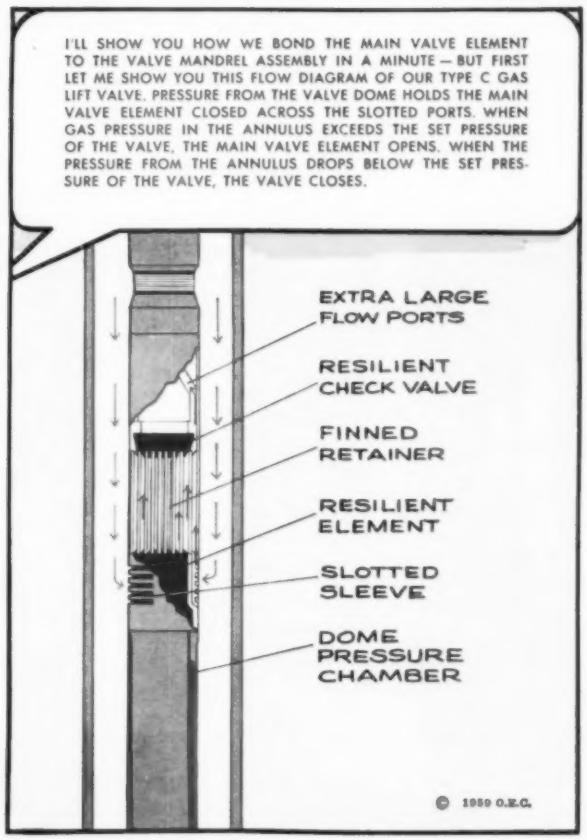
Robert W. Ruhe, Jr., *is staff service engineer in the drilling mud department of Magnet Cove Barium Corporation. He received a BS degree in petroleum engineering in 1950 from the University of Oklahoma. Prior to his present position, he was sales and service engineer with Eastman Oil Well Survey Company. He is a member of the API-AAODC education committee on blowout prevention and a member of API district study committee on factors affecting drilling rate.*

Until very recently, little attention has been paid to the type or quality of the fluids used in working over wells. In fact, it was not until equipment was developed to control the deep, high-pressure wells that anything other than very simple fluids were required. These simple fluids were usually lease brines or crude oil. In a few cases, where viscosity was desired, clays were added to the brine. However, little or no attention was given to the possibility of damaging the reservoir or to stimulating production with additives to the workover fluid.

Planning a Workover

When organizing or planning a workover program, the reservoir characteristics and the reason for the workover should be carefully reviewed. The cause of the problem may be inherent in the type of drive in the reservoir or it may be connected with the normal depletion of the reservoir. After studying the character and nature of the reservoir, the reservoir rock itself — the porosity, permeability, and lithologic character — should be analyzed. This will often lead to a complete re-evaluation of producing practices.

Attention should also be given to


I'LL SHOW YOU HOW WE BOND THE MAIN VALVE ELEMENT TO THE VALVE MANDREL ASSEMBLY IN A MINUTE — BUT FIRST LET ME SHOW YOU THIS FLOW DIAGRAM OF OUR TYPE C GAS LIFT VALVE. PRESSURE FROM THE VALVE DOME HOLDS THE MAIN VALVE ELEMENT CLOSED ACROSS THE SLOTTED PORTS. WHEN GAS PRESSURE IN THE ANNULUS EXCEEDS THE SET PRESSURE OF THE VALVE, THE MAIN VALVE ELEMENT OPENS. WHEN THE PRESSURE FROM THE ANNULUS DROPS BELOW THE SET PRESSURE OF THE VALVE, THE VALVE CLOSES.
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RESILIENT CHECK VALVE
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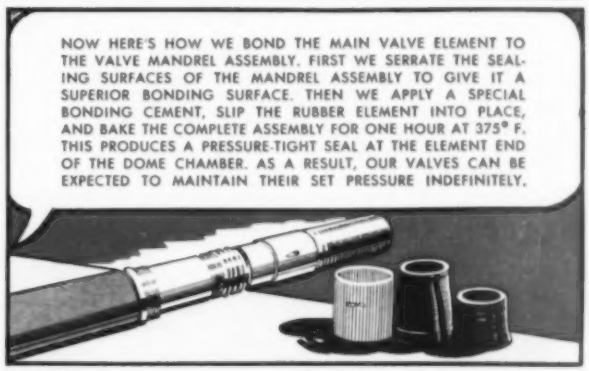
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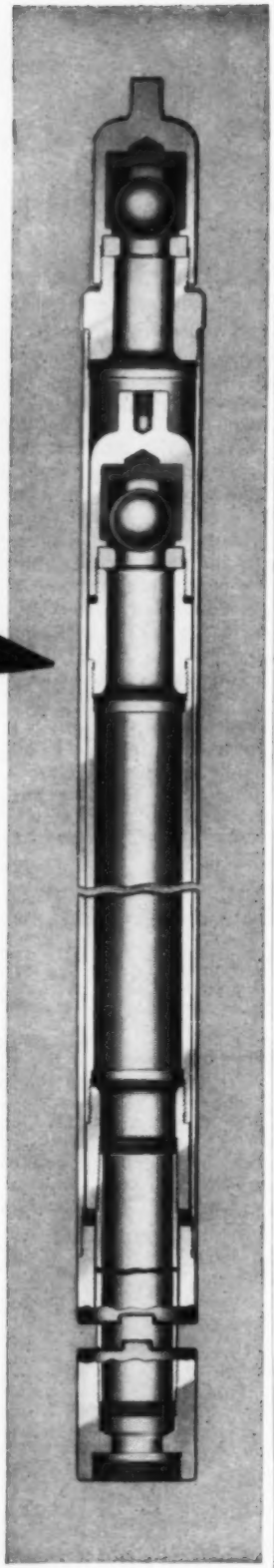

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the nature of the produced fluids. Minor changes in the physical properties of the crude oil often develop as the natural gas-oil ratio falls with depletion of the gas cap. Likewise, produced formation water can greatly alter the productive capacity of the producing formation.

A thorough review should be made of completion practices and operations at the time the well was initially completed. A review of the producing history, as well as all previous workovers, will expose reservoir damage resulting from poor practices which may not have been immediately apparent.

Reservoir Damage

Drilling muds and cementing operations can cause serious reservoir damage. Mud solids, mud filtrate, and cement water can also cause serious producing problems, particularly in low pressure, partially depleted, or water-sensitive sands. All muds, regardless of the fluid phase, are believed to filter under drilling conditions. This filtration results from the differential pressure between the hydrostatic head of the mud and the formation pressure. By reducing the mud weight to a safe minimum pressure differential, the mud invasion problem can be controlled. With modern mud techniques filtration should not be a serious problem. However, if a drilling mud was responsible for reservoir damage, this type of mud should not be used for the workover fluid.

With the advent of gel-cements and low fluid-loss additives for cements, the problems created by cement-water invasion of a formation have been greatly reduced. However, so long as drilling muds and cement are required for drilling and completion, the problems cannot be completely eliminated, but must be controlled with the most modern fluids, techniques, and technology.

While a knowledge of reservoir mechanics and fluids is extremely important, the operations of the workover must also be considered. These, in many cases, can be just as important in the proper selection of the workover fluid as the reservoir conditions. When simple operations are to be performed, such as repair or replacement of downhole equipment, pumps, tubing, sucker rods, slotted or screen liners, etc., simple inexpensive fluids will perform satisfactorily.

However, when major repairs such as patching casing, control of water encroachment, high gas-oil ratio or recompletion, are undertaken, a more stable and often more expensive fluid should be used to expedite the operation and provide better protection to the exposed producing reservoir.

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Types of Workover Fluids

Workover fluids may be divided into two groups — available fluids and prepared fluids. Available fluids are those immediately available from nearby storage. These include lease or commercial brine solutions, crude oil, or drilling muds from a nearby drilling site or from reserve storage on the lease or field. An advantage of these fluids is that they may require little or no conditioning before they are ready to use. A disadvantage is that their chemical environment may not be such that they will remain stable under conditions in the well or during the prescribed operations.

The prepared fluids are for the most part drilling muds adapted to meet the needs of the workover operation. These muds offer an advantage in that they can be formulated to offer the maximum protection to the reservoir and at the same time reduce subsequent conditioning time to a minimum.

Prepared workover fluids may be classified in much the same manner as drilling muds. This classification is based on the external environment as follows:

A. Water base muds

1. Fresh water muds

These muds are usually classified as low pH and are the cheapest type to prepare. They are excellent muds for routine workover operations at low densities. However, these muds offer the least resistance to contamination from cement and salt water.

2. Salt water muds

Salt water muds are becoming more popular because they utilize available lease brines, or in the case of water locations, sea water. While slightly more expensive than fresh water muds, they offer increased protection to the reservoir and resistance to contamination. Fresh water muds, or muds having a salinity less than formation water, can cause swelling of hydratable clays which blocks flow channels and reduces well productivity. Reservoir engineers believe that a mud whose salinity is equal to or greater than formation water salinity will eliminate reservoir damage from filtration invasion.

3. Inhibitive and surfactant muds

Inhibitive muds, such as shale control and gyp muds, are those whose chemical environment is such that clays coming in contact with them will be prevented from swelling. While these muds are the most expensive of the water-base muds to prepare, they offer the greatest resistance to contamination, remain stable with time and temperature, and are the most versatile of the

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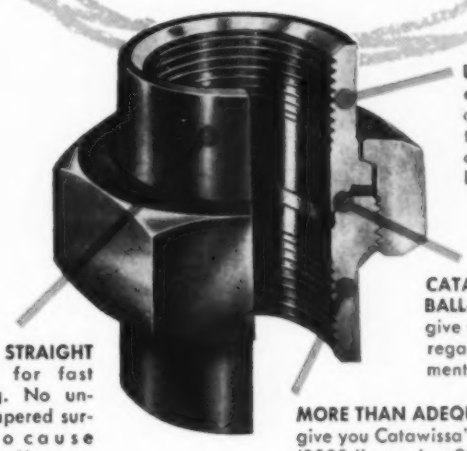

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water-base muds. They offer the greatest protection to a water-sensitive formation.

The use of surface-active materials in drilling and workover muds has been a major advance in mud technology. With these surfactant systems, operators are able to obtain maximum protection of the producing formation. Many operators now feel that they can achieve the same benefits by using surfactants in muds as they do from subsequent treatment with surfactants. At the same time, they gain production normally lost through additional off-production time for the subsequent treatment.

B. Invert emulsion and oil-base muds

1. Invert emulsions

These are not true oil-base muds, although oil is the external phase. They perform in the same manner as oil-base muds, but their advantage lies in their economy. Their cost of preparation is about one-half that of an oil-base system for any given density.

2. Oil-base muds

True oil-base muds, unlike invert emulsions, contain little or no water. These systems are stable to most contamination. Unlike the invert emulsions they cannot tolerate water dilution or contamination.

C. Treated brines

1. Brines prepared with sodium chloride, sodium nitrate, or calcium chloride have recently found use as packer fluids at densities up to 12 lb per gal. Saturated salt brines have for many years been used extensively on workover operations. Brines prepared with other salts should find greater acceptance in the future.

2. Any of the above mentioned brines may be treated with various surface active materials to reduce possible reservoir damage from loss of the fluid to the formation.

The selection of the right workover fluid should be made on the basis of three considerations: (1) Protection to the reservoir; (2) stability; and (3) economy.

Mud Characteristics

To offer maximum protection to the reservoir, the workover fluid should offer a condition of minimum hazard to the producing formation. Where weighted systems are required, the mud should contain a minimum amount of solids. It is particularly important to use inhibitive fluids when dealing with low pressure, partially depleted or water-sensitive formations. A low surface tension filtrate is also desirable so

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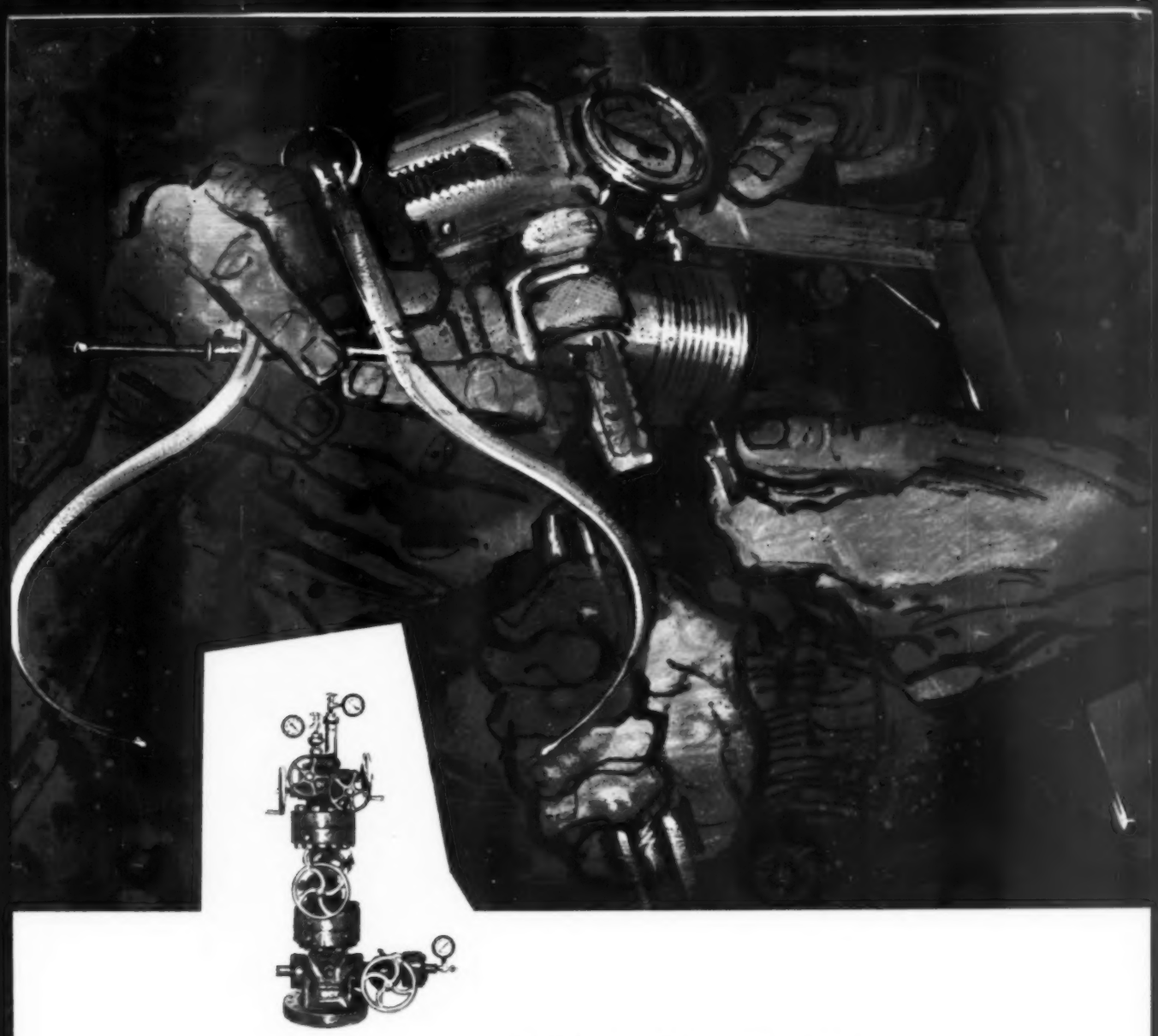

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that the possibility of water blocking is reduced or eliminated.

The mud should remain stable throughout the workover. This means that fluid intrusion from the formation and cement should not appreciably alter physical or chemical properties of the fluid. Furthermore, the fluid should inhibit corrosion. For example, chromates have for many years been used extensively to reduce the corrosive nature of salt brines and salt water muds.

Economy in Workovers

It is difficult to justify the use of a particular system on the basis of cost alone. Frequently, the protection to the producing formation and the expediting of the operations cannot be accurately determined in dollars and cents. The system costing more to prepare initially can often result in a less expensive overall operation by reducing mud maintenance cost and eliminating lost time for conditioning mud.

Operating under our present economic structure, some oil producers tend to attempt short cuts because of the low profit per barrel of crude oil resulting from higher taxes, increased material and labor costs, and reduced producing allowable. Under these conditions, it is imperative that more forethought and planning be given to each workover program. Workover fluids must be selected with more care. Often, a few extra dollars spent on the workover fluid can be more than returned by increased production and elimination of an expensive fracture and/or acid treatment.

INVERT EMULSION MUDS

In conventional oil-emulsion mud, minute oil droplets are dispersed in a continuous water phase. In such a mud, water is the external phase and oil is the internal phase. This is commonly known as an "oil-in-water" emulsion.

In "invert" emulsion mud, minute water droplets are dispersed in a continuous oil phase. Oil becomes the external phase and water the internal phase to form what is commonly known as a "water-in-oil" emulsion. Control of such an emulsion is obtained by a chemical emulsifier. Satisfactory systems can be made with 50 percent oil, 50 percent water, and from 25 to 40 lb of emulsifier per bbl of fluid. Either fresh or salt water can be used as the internal phase.

17-Well Program

A major oil company in Southwest Texas saved approximately $58,166 by using an invert emulsion mud* as a workover and completion fluid in a 17-well program. Prior to this program,

*Data in this report are based on the use of No-Blok, a product of Magnet Cove Barium Corporation.

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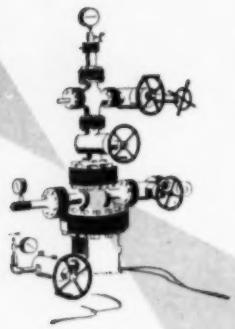

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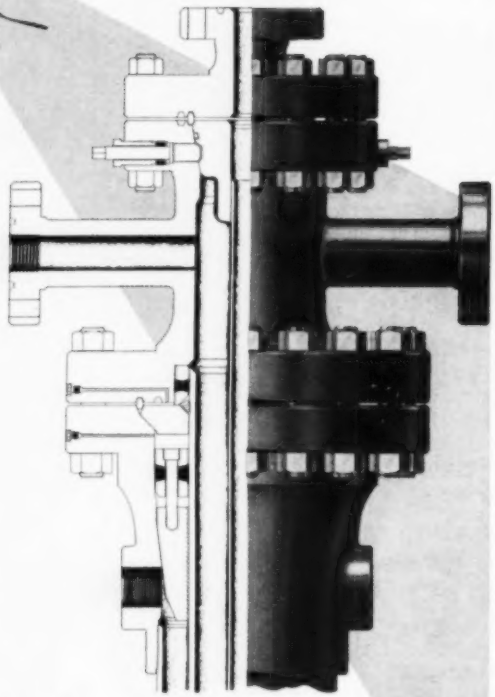

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the company had used salt water and water-base mud as the workover fluid in this field. The severe water block condition and high workover expense of the previous fluid were virtually eliminated with the invert emulsion mud.

In this field, the operator traditionally experienced blocking of the producing formation by salt water, drilling mud, or mud filtrate. The majority of the wells in the field were originally completed with drilling mud in the hole. The usual practice was to perforate the well with mud in the hole, and then displace the mud with salt water prior to swabbing the well in. Prior to the initiation of the invert emulsion program, most of the workover operations were performed with salt water or water-base mud, with these in some cases being displaced with crude oil before swabbing the well in.

During a one-year period, following the initiation of the invert emulsion program, the emulsion mud was used on 17 jobs, including several pulling jobs, repairs, and recompletions, and one original completion. Virtually no difficulty with water or mud blocks in the formation occurred in these 17 wells.

Field Performance

Among the advantages noted in using the invert emulsion was the ease with which wire line tools were run. Also, on jobs involving dual tubing strings equipped with gas lift valves, running and pulling the tubing was easier than when salt water and water-base mud were used. This is apparently due to the excellent lubricating properties of the invert emulsion. Keeping the hole full was seldom a problem. Subsequent use of invert emulsion muds has proved that they are highly successful as workover and completion muds in fields where formations tend to take water and oil.

It is not possible to estimate closely the money saved by using the invert emulsion mud as it was used as a preventive measure. However, an idea of the economical advantage gained may be obtained by a comparison of the results of work in the same field before and after the installation of the invert emulsion system.

During a 6-month period immediately preceding the initiation of the invert emulsion program, a total of 20 workovers were performed in this field. These involved loading the hole with water-base mud and pulling tubing. A number of these were dual completions in which only one zone required attention.

As a result of these 20 jobs, 9 formation blocks occurred, and approximately $3000 per well was spent in

attempts to restore production in these 9 wells. Eight of these wells were subsequently restored to top allowable production of 75 bbl per day with one being limited to 9 bbl per day marginal production. The average production loss was approximately 3 months per well based on an average producing day pattern of 16 days per month during the 6-month period.

On this basis, the estimated loss of oil production from these 9 wells amounted to 29,600 bbl valued at $74,000. There was an additional estimated treating expense of $27,000 for the 6-month period. These figures do not include the loss of production from other zones of dually completed wells while attempts were being made to restore production in the blocked zones.

Cost Comparison

The following is comparison of costs relating to the formation blocks prior to initiation of the invert emulsion program and the estimated saving which resulted during the one-year period in which the emulsion mud was used.

Jobs prior to installation of the invert emulsion mud:*

Number of jobs	20
Number of formation blocks	9
Estimated loss of oil production from blocked formations	29,600 bbl
Estimated value of lost production (at $2.50 bbl)	$ 74,000
Estimated cost of treating blocked formations	27,000
Total estimated cost due to formation blocks	$101,000
Average producing days per month—16	

Jobs using the invert emulsion mud:

Number of jobs	17
Estimated possible formation blocks without invert emulsion	8
Estimated possible loss of oil production	18,100 bbl
Estimated value of possible lost production (at $2.50 bbl)	$ 45,250
Estimated cost of treating blocked formations	24,000
Estimated total possible cost due to formation blocks	$ 69,250
Cost of using invert emulsion mud	11,084
Estimated net savings	$ 58,166
Average producing days per month—11	

Summary of Cost Data

General data:

Number of jobs using invert emulsion	17
Mud weight range	8.7-9.2 lb/gal

Initial system data:

Volume of system	250 bbl
Mud weight	8.8 lb/gal

*All figures shown furnished by the operator.

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Material used:		
Lease salt water	100 bbl	———
Lease crude oil	150 bbl	———
Emulsifier (100 lb/sack)	12,500 lb	$1,584.00
Salt (100 lb/sack)	10,000 lb	175.00
Total material cost		$1,759.00
Hauling (water and oil)		323.00
Total cost of system		$2,082.00
Initial cost per bbl		$ 8.33
Individual job data:		
Minimum volume used	200 bbl	
Maximum volume used	350 bbl	
Average volume used per job	268 bbl	
Average material cost per job		$ 502.00
Average hauling cost per job		250.00
Average mud cost per job		$ 752.00
Comparison of costs:		
Average cost of using invert emulsion mud per job (not including value of oil)		$ 752.00
Average estimated cost of using salt water and/or oil per job (hauling only)		100.00
Average difference in cost per job		$ 652.00
Total difference in cost (17 jobs)		$11,084.00

The estimated saving of $58,166 is, of course, a theoretical figure based on the formation block ratio which prevailed prior to the initiation of the invert emulsion system. However, in view of this saving, the operator feels that the added expense of using the invert emulsion mud was completely justified.

This description of an actual operating condition has been presented as an example of how one operator has used a more expensive workover fluid to combat a particular problem. At the same time, he realized a savings through elimination of loss production and subsequent remedial treatment. Many times the few extra dollars spent on analyzing the problem and the selection of the right, though often more expensive, workover fluid can result in savings such as those shown here.

In times such as these, when many operators are faced with very limited operating budgets due to limited producing allowables, these savings can be turned into profits by reducing the off-production days for workovers and, many times, the frequency of workovers. ★ ★ ★

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Chapters Complete Officer Selections

New officers of the Los Angeles Chapter of Nomads were inaugurated at the Twentieth Annual Inaugural Ball, February 14, 1959. They are: Bob Gaylord of Wagner-Morehouse, senior regent; Art Marshall of H. C. Smith Oil Tool, deputy sergeant-at-arms; Andy Anderson of Pacific Perforating, sergeant-at-arms; Earl Daniels of Hydril, junior regent; Harry Hester of McCullough Tool, master of ceremonies; Tom Ashe of Globe Oil Tools, president; Taylor Bannerman of TOTCO, vice president; Knight Templeton of Bowen-ITCO, treasurer; Charlie King of Baker Oil Tools, assistant secretary; P. M. Bowen of Martin-Decker, assistant treasurer. Not shown, Leo Cypher of Baash-Ross Tool, secretary.

First Meeting of new officers of the Tulsa Chapter Nomads brought together this group at a recent luncheon. They are, seated from left, Ray Carter, Triangle Oil, on the planning committee for the group's inaugural ball last January; John Pearce, Superior Iron Works and Supply, senior regent; Oscar Irizarry, Petroleo Interamericano, president; and Harry Horton, Tret-O-Lite, assistant secretary. Standing are Guy Williams, Dowell, retiring senior regent; W. O. Timberlake, Lucey Products, secretary; Vern Bailey, Bethlehem Supply, assistant treasurer; James Young, Reed Roller Bit, on the dance planning committee; Floyd Cummings, Axelson Manufacturing, treasurer, and E. M. Donovan, Martin-Decker, Oklahoma City, sergeant-at-arms. New officers not present at the meeting were Paul McGivern, McKissick Products, vice president; Thomas M. Lumly, The Refinery Engineering Company, junior regent, and R. R. Mathews, Alten Foundry and Machine, deputy sergeant-at-arms.

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"Of Course I said RIDGID . . . It's the only pipe wrench for my money. I've got work to do!"

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The Ridge Tool Company Elyria, Ohio, U.S.A.

THREADED PIPE . . . *It's Tight . . . It's Best . . . Costs Less!*

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where engine dependability is vital!

the only lubricant that has
over 35 years of proven superiority... a record of less costly maintenance, "down time", stoppages and repairs than any other make.

MARVEL extra-fine lubricant is specifically designed to keep engines at peak efficiency under all the "engine-killing" conditions... in an oil field.

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TO BE SURE OF "ROUND-THE-CLOCK" PROTECTION.
Feeds MARVEL Mystery Oil in exact proportion to engine speed and load.

Contact your jobber or Oil Well Supply House

MARVEL DIVISION
EMEROL MFG. CO., Inc. • 331 North Main Street, Port Chester, N. Y.

The Oasis

Nomads elected to fill offices of the Houston Chapter are: James B. Hughes, senior regent; B. J. Gross, assistant secretary; F. S. Mims, treasurer; J. C. Woods, sergeant-at-arms; J. B. Jones, secretary; B. H. Pickard, president; John W. Gates, vice president; A. C. Oden, deputy sergeant-at-arms; E. W. Louden, immediate past president and junior regent. Bruce Barkis, assistant treasurer, is not shown.

Dallas-Fort Worth Chapter Nomads 1959 officers shown here are (front row) J. Lewis Foster, vice president, regional; J. A. Kelly, vice president, Dallas; Tom E. Morton, vice president, Ft. Worth; G. H. Lewis, senior regent; (back row) K. Marshall Fagin, treasurer; Rollo E. Davidson, junior regent; R. E. Elmore, president; and Harry S. Zane, executive vice president. 1959 Officers not pictured are Robert H. McLemore, secretary; G. A. Holloway, assistant secretary; George Pfefferle, assistant treasurer; L. D. Webster, sergeant-at-arms and Webb Sowden, deputy sergeant-at-arms.

Group of New York Chapter officers include (seated) Junior Regent E. E. Andreason, Andreason-Lundberg Corp; Vice President Hollis W. Haltom, Beckley, Haltom and Hickman; President Don E. Kircher, Gardner-Denver; Executive Secretary Edward W. Hoeppner, Hughes Tool; James M. Taylor (asst. secretary), American Iron & Machine Works; (standing) Secretary W. E. Volkman, Cardwell Manufacturing; Asst. Sgt.-at-Arms R. L. Faris, Mission Manufacturing; Treasurer H. E. Lowrey, Continental-Emsco; Asst. Sgt.-at-Arms J. E. George, Mid-Continent Supply; Sgt.-at-Arms D. T. O'Connor. Unavailable at the time the photograph was taken were Senior Regent Maurice F. Delano, Jr., R. S. Stokvis & Sons, Inc.; Asst. Treasurer J. W. Chanda, A. O. Smith.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Pearce, Lumly Named Nomads Regents

John Pearce

The National Board of Regents of Nomads has named John Pearce as its chairman, and Thomas M. Lumly, Jr., as secretary-treasurer for the ensuing Nomads year. Both are regents of the Tulsa chapter.

Born in Youngstown, Ohio, Pearce gained his BS degree from Miami, (Ohio) University. He has traveled in the Orient, Mexico and Canada, and represents the Superior Iron Works & Supply Company.

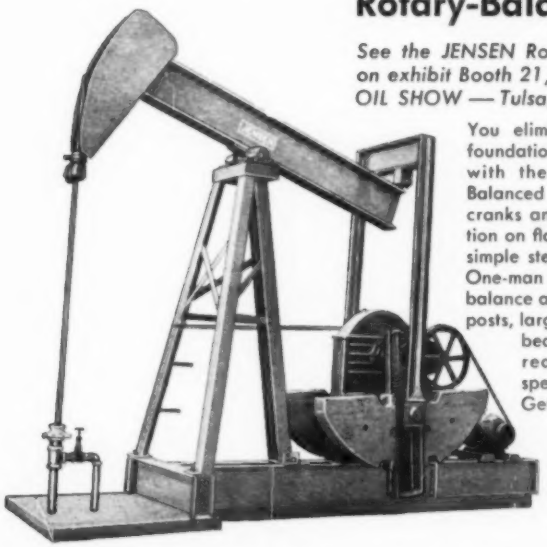
A graduate of OSU, Lumly is the founder and president of The Refinery Engineering Company. He is a member or director of several prominent Oklahoma engineering societies, a recipient of the Richards Memorial Award, and was elected to the Oklahoma State University Alumni Hall of Fame in 1956.

Thos. M. Lumly, Jr.

NOTICE

The Dallas-Fort Worth chapter of Nomads have instituted Tuesday luncheon meetings to be held on the first and third Tuesdays of each month for exchange of then current foreign traveler information. These meetings, strictly informal, will be held at the Crossroads Restaurant on the Dallas-Fort Worth Turnpike near Arlington on each meeting day.

It pays to specify **JENSEN**
Rotary-Balanced JACKS



See the JENSEN Rotary Jack on exhibit Booth 21, Kansas Bldg. OIL SHOW — Tulsa, May 14-23.

You eliminate expensive special foundations and crank weight wells with the new JENSEN Rotary-Balanced JACK. Its floor-clearing cranks and weights permit installation on flat concrete surfaces or on simple steel sub-structures.

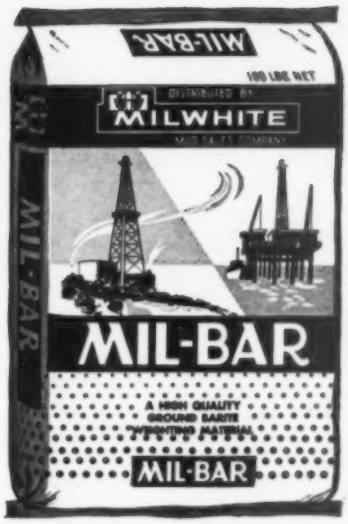
One-man rack-and-pinion counterbalance adjustments, larger samson posts, larger and heavier shafts and bearings — are additional reasons why it pays to specify JENSEN R-B JACKS. Get *all* the facts and figures before you equip your next well — a call or card will bring it to you *fast!*

STOCKED BY YOUR LOCAL SUPPLY STORE

Made by JENSEN BROS. MFG. CO., INC., P. O. Box 477-B, Coffeyville, Kansas

Export Office: 250 Park Avenue, New York 17, N. Y.

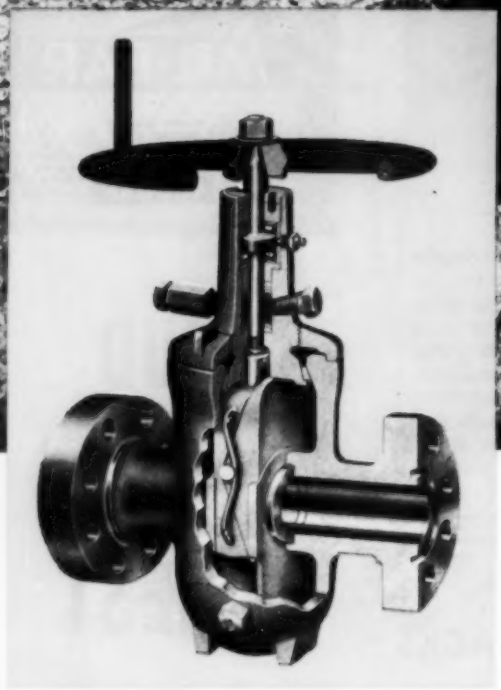
JENSEN JACKS



MUD
of the
FINEST
QUALITY
POSSIBLE

MUD SERVICE BY
MILWHITE *Pays!*

MILWHITE
MUD SALES COMPANY
HOUSTON, TEXAS
A DIVISION OF MISSISSIPPI RIVER FUEL CORPORATION



Practical advantage of W-K-M's *Creative Engineering*:

On-the-line overhaul!

Fast, easy overhaul of W-K-M Gate Valves while on the line saves you time and money and contributes to the overall efficient performance and long-range economy that W-K-M valves are noted for.

Other benefits include parallel expanding gates, controlled force seating, free flow through the valve without any more turbulence or pressure drop than through a smooth-wall pipe, Teflon seat inserts (in all valves up to 5,000 psi working pressure), and superfinished stems.

Available in standard types, balanced stem*, recessed body, dual and triple completion types. Sizes range from 1½" through 7" for pressures ranging from 500 to 15,000 psi working pressure.

** Illustrated above right*

Completely dependable

The superior performance of W-K-M production valves is attested by the experience of users.

These valves have earned a reputation that inspires confidence throughout the world. Field men recommend them; engineers specify their use.

W-K-M valves set industry standards for design . . . reliability . . . easy operation . . . and long-range economy.

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The most used sizes of W-K-M gate valves are carried by supply stores everywhere. Special sizes and special designs are produced as you need them.

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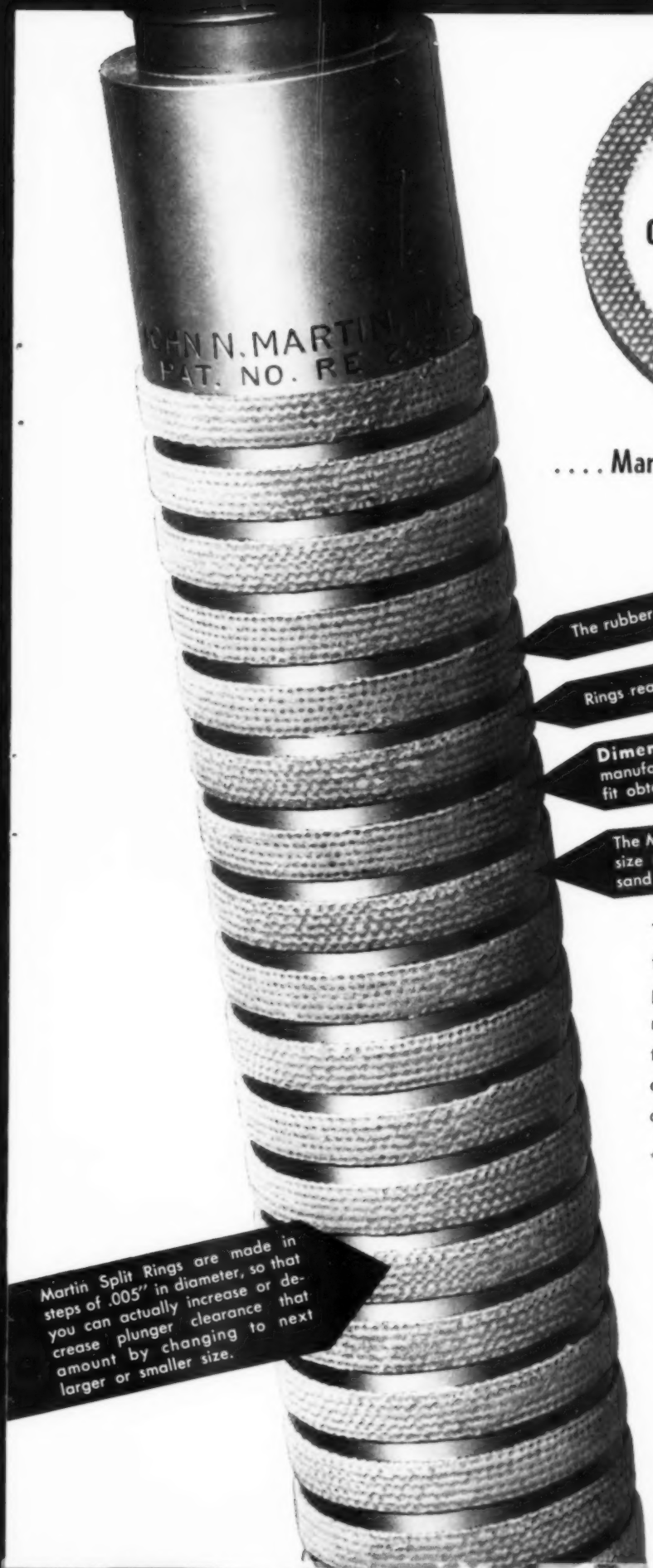
P. O. BOX 2117, HOUSTON, TEXAS
Export Office: 45 ROCKEFELLER PLAZA, NEW YORK, N. Y.



GETTING CORRECT RING FIT IS EASY WITH

.... Martin Plungers and the Martin Method of Installation*

The rubber-and-duck rings swell **just so much** and no more.

Rings reach maximum size in the well within a few hours.

Dimensional Compensation during the manufacturing process assures the uniform working fit obtained with Martin Split Rings.

The Martin Ring Size Guide Table* assures proper ring size selection for various gravities, temperatures and sand and water content.

Martin Split Rings are made in steps of .005" in diameter, so that you can actually increase or decrease plunger clearance that amount by changing to next larger or smaller size.

The gaps between the Martin Rings cause fluid turbulence which slows down slippage past the Martin Plunger — just as a rough road slows down your driving speed. Actually, the Martin Plunger maintains pumping efficiency with a looser fit than is possible with a smooth surface plunger.

* See the complete Martin Catalog and instructions in the 1957 Composite Catalog.

JOHN N. MARTIN

Manufacturer

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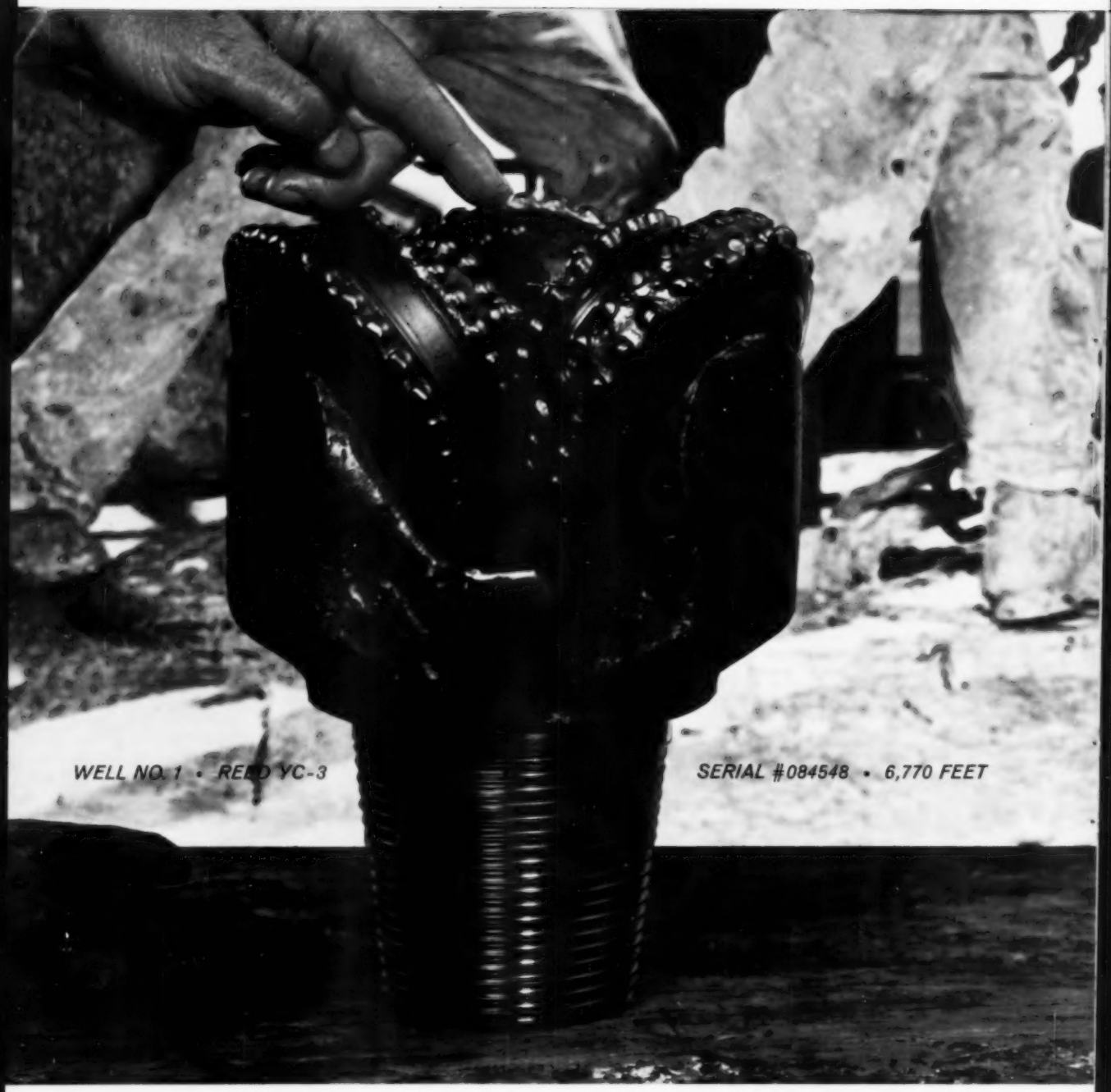


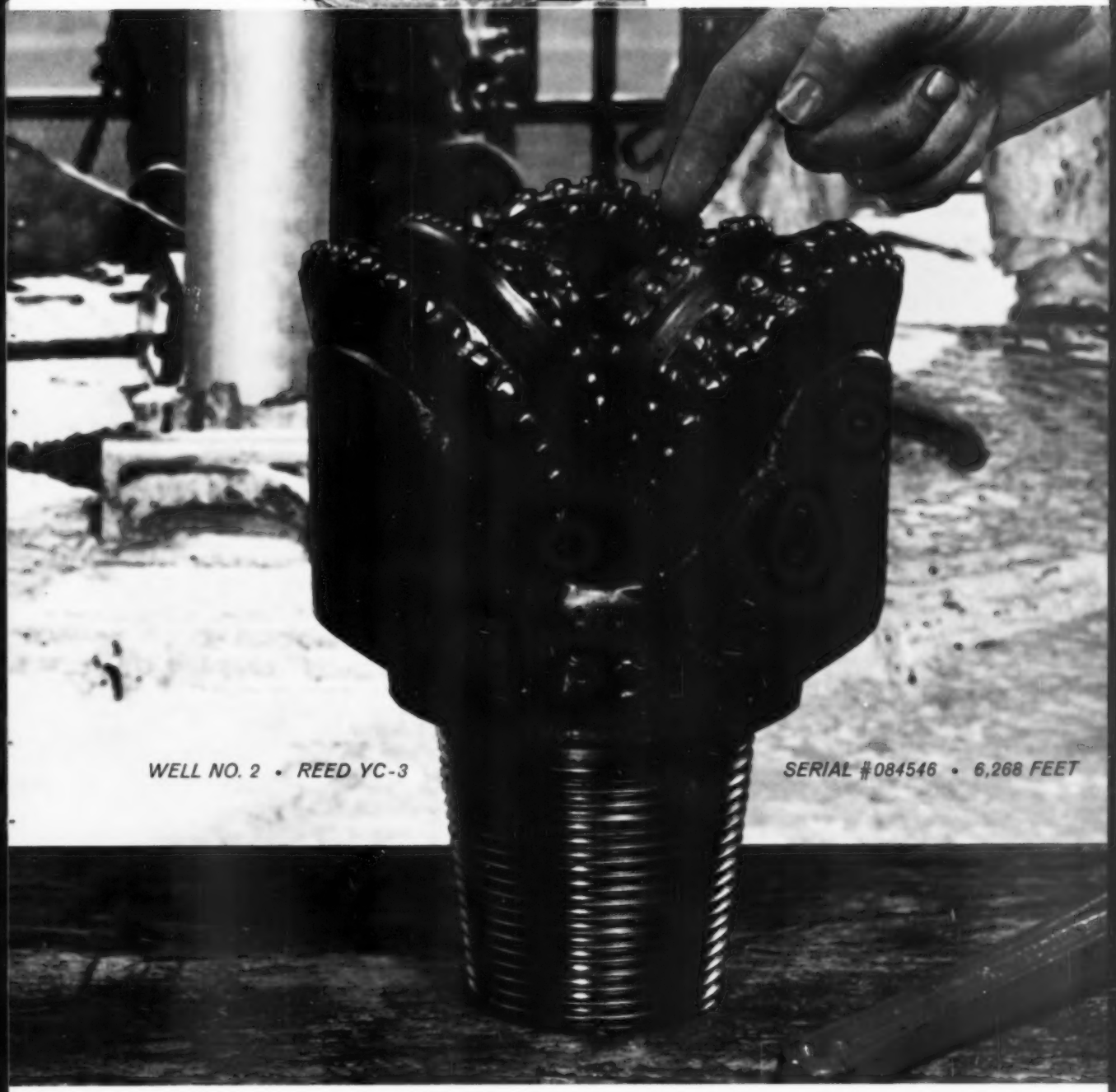
TWO BITS... TWO WELLS... TO

These two Reed Cobra bits *each* completed the entire 8¾" portion of a hole—from surface hole to bottom. One bit cut 6,770 feet in 152 hours. The other cut 6,268 feet in 98 hours.

Spectacular runs by Reed Cobra bits are becoming commonplace. Have you tried them lately, all the way? Your Reed representative will be glad to give you the whole story on these bits—and the complete line of Reed products.

REED ROLLER BIT COMPANY *Houston 1, Texas*

EXPORT OFFICE: 1011 INTERNATIONAL BLDG., NEW YORK 20, N. Y. GULF COAST, MID-CONTINENT, ROCKY MOUNTAIN AND CANADIAN DISTRIBUTOR FOR MARTIN-DECKER PRODUCTS.

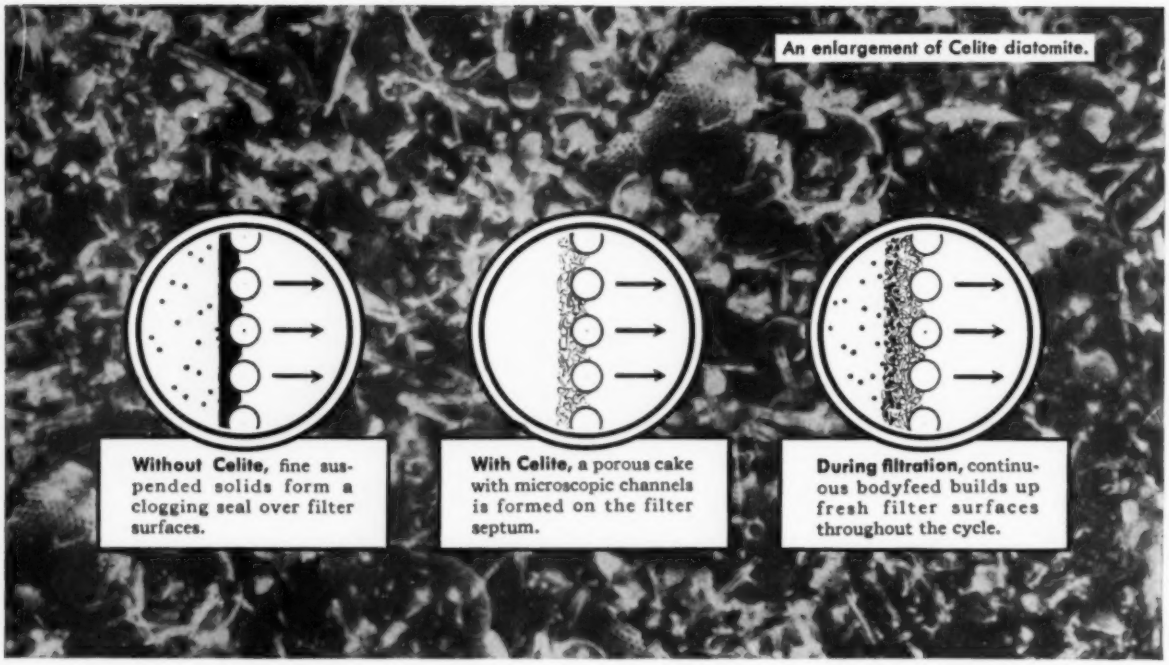


COMPLETION – 13,038 FEET

REED

REED'S ROLLIN'

REED BITS


An enlargement of Celite diatomite.
Without Celite, fine suspended solids form a clogging seal over filter surfaces.
With Celite, a porous cake with microscopic channels is formed on the filter septum.
During filtration, continuous bodyfeed builds up fresh filter surfaces throughout the cycle.

How Celite's 2,000,000 tiny channels per cu. in. remove all suspended solids from injection water!

These small, movable, skid-mounted filters can only be used with diatomite filtration.

Celite is Johns-Manville's registered trademark for its diatomaceous silica products.

THESE CHANNELS—so small the unaided eye can't see them—take all the pore-clogging, suspended solids out of repressurizing water in injection systems. They are so tiny they even remove algae and amoebae, yet they provide the fastest flow rates.

To you, this means maximum clarity of injection water. It also means fast, economical operation from a plant that uses ten times *less space* than other systems. When cleaning is needed, minimum backwashing removes the cake, quickly and cleanly.

Because of the wide variations in filtration problems, Celite is processed into 9 standard grades to meet every requirement. And Celite gives you consistently better results because it is more uniform from bag to bag than any other diatomite.

A Celite filtration engineer is available to assist you on your injection water problems. Call your local J-M office or write Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

JOHNS-MANVILLE

JOHNS-MANVILLE JM PRODUCTS

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SAFETY FOR ANY RIG

Shallow, deep, land, offshore, or rework—no matter what kind of well you are drilling or what kind of rig you are using, Payne hydraulic power for blowout preventers and pressure operated gate valves will give you the greatest safety and economy. Our non-separator type accumulators require no pistons, bladders or diaphragms. Each twenty gallon accumulator contains a free-moving metal float which takes the place of rubber goods. Any volume of fluid is available with multiple units. Payne fast-acting automatic pumps keep accumulator pressures at 2,000 psi for normal operation and produce instant additional pressure for emergencies. Payne Controls may be located at one or several positions on the rig for maximum safety and convenience.

If you are not now protected by these advanced Payne products, ask anyone who is (they are in use throughout the world) or give us a call—you'll be glad you did.

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RUNNING TOUR

▸ **Jack Menneer,** petroleum engineer and former chief engineer for the Anglo-American Exploration Company in Canada, has joined Stekoll Petroleum Company as manager of its exploration department in Calgary. Assisting Menneer in the enlarged activities of the American independent producer will be **Peter Watkins,** also of Calgary.

Menneer will take over direction of the Stekoll exploration department from **John Bonds,** Stekoll partner, who moves to Los Angeles as investment manager of the Stekoll operation. Menneer was drilling and production editor of *The Petroleum Engineer* in Dallas 5 years ago.

Jack Menneer

A. M. Shook

▸ **Mack G. Trusdel** has been promoted to district superintendent, Harvey district of the New Orleans division, Texaco, Inc. **A. M. Shook** will be transferred from Houston division to New Orleans as division petroleum engineer, succeeding Trusdel.

R. C. Shields was named to succeed Shook. Shields was a petroleum engineer on the staff of the general manager of domestic producing department.

L. A. Kuebler, former district geologist of the Houston district, has been promoted to the position of assistant division geologist of Texaco's producing department.

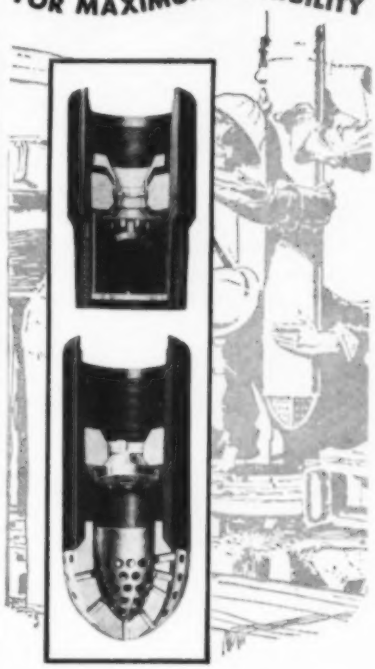
The former Houston district area has been divided into two districts east and west of Houston. **Ralph A. Davis** and **Morris W. Wylie** have been appointed district geologists of these areas, respectively. **Claud M. Watts** succeeds Ralph A. Davis as development geologist on the division geological staff.

▸ **Harold G. Freedman** announced his resignation as division engineer of production of Continental Oil Company's North Texas-Panhandle division to accept the position of manager of production and exploration for Wolfson Oil Company of Dallas.

▸ Two Shreveport men, **Fred M. Odom Jr.,** and **C. A. Sullins,** have been named to the board of directors of Union Producing Company. Re-elected to Union's board of directors were **N. C. McGowen,** chairman of the board; **W. H. Spears,** executive vice president; **J. H. Miracle,** vice president and treasurer; **E. L. Rawlins,** vice president; **F. R. Schroeder,** vice president, and **J. B. Storey,** vice president.

▸ **G. A. Schurman** has been promoted to manager — producing research, development and technical service, California Research Corporation, research subsidiary of Standard Oil Company of California, at the La Habra, California, laboratory. In his new assignment Schurman will be responsible for all activities in drilling, well logging, reservoir mechanics and secondary recovery.

RECTOR
Type "O" Fill Shoe and Collars
FOR MAXIMUM FLEXIBILITY



Rector Type "O" is the only automatic casing fill equipment that permits you to stop running pipe and circulate the well as often and for as long as you want and then resume running pipe with controlled orifice fill after circulating.

Only Rector Type "O" Gives You These Advantages:

- **Automatic fill-up increases safety—speeds running time—reduces pressure surges—protects the formation.**
- **Orifice choke in the spring-loaded flapper valve assures controlled constant fill.**
- **Precision rubber molded section on aluminum flapper valve assures positive back-pressure valve.**
- **Ceramic choke inserts are easily changed, making field maintenance easy, fast.**
- **Converts to float at operator's option.**
- **Internal parts are easily drillable aluminum alloy.**

Available through your favorite supply store for use in casing sizes 4" O.D. through 20" O.D. with standard threads.

RECTOR
Well Equipment Company, Inc.
1100 North Commerce Fort Worth, Texas
Houston Plant: 2215 Commerce
EXPORT REPRESENTATIVES:
Continental-Emsco Co.; Mid-Continent Supply Co.; Oil Well Supply Division of United States Steel Corp.

DON'T WELD ON CASING!

B and W

FRICTION-LOCK CLAMPS

give you these distinct advantages in mounting scratchers and centralizers:

LOWER COST . . . Friction-Lock Clamps cost less than welding when ordered with B and W Scratchers and Centralizers.

WITHSTANDS GREATER THRUST . . . exhaustive laboratory tests prove Friction-Lock Clamps withstand resistance to vertical movement far in excess of average field welding.

ELIMINATES WELDING DAMAGE . . . average field welding may damage casing from undercutting, hard spots and electrolytic corrosion . . . Friction-Lock Clamps cannot damage casing.

ONLY FULL GRIPPING DEVICE . . . only the Friction-Lock Clamp grips uniformly around the complete periphery of the casing . . . other holding devices grip over relatively small areas.

EASIER INSTALLATION . . . B and W Friction-Lock Clamps may be installed in seconds with a simple hex wrench.

ANOTHER FIRST BY THE FIRST NAME IN PRIMARY CEMENTING TOOLS

OTHER B and W PRODUCTS:

Multi-Flex Scratchers • Nu-Coil Scratchers • Rotating Scratchers, Multi-Flex and Nu-Coil Types • Automatic Stop Collars • Stabilizers • Rotator Collars • Liner Centralizers • Latch-On and Solid Type Centralizers • Thread-Lock Cages • Thread-Lock Cement.

B and W Inc.

Well Completion Specialists

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Houston 12, Texas
PHONE WAlnut 3-6603

WEST COAST
19706 South Normandie Ave.
Torrance, California
PHONE FAculty 1-2463

Running Tour

▸ The Billings, Montana, Petroleum Section, Society of Petroleum Engineers, AIME elected the executive officers for 1959. They are (left to right): **Wayne Fincher,** AIME director, McAlester Fuel Company; **Fred A. Haddenhorst,** secretary-treasurer, Mobil Producing Company; **Fraser M. Burback,** director, Mobil Producing; **Gordon Lansford,** second vice president (membership), Halliburton Oil Well Cementing Company; **Charles B. Evans,** chairman, Schlumberger Well Surveying Company; **L. M. Lyon,** first vice chairman (program), The Carter Oil Company. **N. J. Matthews,** director, Shell Oil Company, not in picture.

▸ Formation of a new well logging and core analysis service company has been completed in Houston. The announcement was made by **B. F. Winborn Jr.,** president of Exploration Service Company. Officers of the new organization, in addition to Winborn, are **O. M. Wilkinson,** vice president and sales manager; **Stanley Wondrash,** vice president and instrument manufacturing manager; and **J. W. O'Neal,** secretary-treasurer and general manager.

▸ **John R. Evans** has been appointed general manager of production for Standard Oil Company (Indiana). He has been vice president and division manager of Pan American Petroleum Corporation at Fort Worth, Texas, and will now coordinate production and crude oil supply activities of Standard Oil with operations of such principal subsidiaries as Pan American Petroleum Corporation, Service Pipe Line Company, Indiana Oil Purchasing Company, and Tuloma Gas Products Company.

▸ **Archie L. Crawford** has been named field superintendent for the Ryder Scott Management Company, Wichita Falls, Texas. He previously was foreman and superintendent for Lone Star Producing Company, New Idria Mining & Chemical Company, and Ada Oil Company.

▸ **W. F. Latting Jr.** has been elected assistant business manager of the Society of Exploration Geophysicists.

▸ **John Armstrong** has been named acting chief geophysicist for Cities Service Oil Company at its Bartlesville, Oklahoma, headquarters. He steps up into the new position to replace **R. M. Bradley,** who is being transferred to Africa-Cities Service Petroleum Corporation in Alger, Algeria, on a temporary assignment. **Gene Current** is being promoted from assistant division geophysicist at Lafayette, Louisiana, replacing Armstrong as division geophysicist for the southwestern division at Midland.

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Since 1922

PETROLEUM ENGINEERS
CABLE & STEPHENS
WICHITA FALLS, TEXAS

RESERVOIR ENGINEERING
Water Flooding **Gas Repressuring**
EVALUATION CORE ANALYSIS
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INCREASE PRODUCTION

CLEAN OUT CHOKING SAND

Excessive sand and sediment holds back your oil. For fast, easy cleanout with fewer round trips and less downtime, use world famous Miller Sand Pumps.

Write for descriptive price list.

SAND PUMP SIZES IN STOCK

O.D.—2½, 3, 3½, 4¼, 5, 5½, 7 in. Lengths, 20, 25, 30 ft.

Composite Catalog Page 3400

MILLER SAND PUMPS

Miller Sand Pump Co.
General Offices, Box 4516
Oklahoma City 9, Okla.

EXPORT OFFICES
30 Rockefeller Plaza
NEW YORK 20, N. Y.

J. J. Reynolds has been promoted to chief engineer in Continental Oil Company's production department, with headquarters in Houston. Formerly director of production research for Conoco, he succeeds **M. H. Dubrow,** who recently was promoted to assistant manager of the production department. **Dr. H. F. Coffer** has been promoted from assistant director to director of Conoco's production research division, succeeding Reynolds.

J. J. Reynolds

R. H. Vick

Ambassador Oil Corporation of Fort Worth has formed a consolidated engineering department combining three previously separate departments and named **Robert H. Vick** manager of engineering. **J. D. Christner** has been named assistant to Vick and will continue as chief primary engineer. **Russell Meyers** is senior petroleum engineer in the new department.

Carl J. Hauck has been promoted to assistant manager of the production department of the Ohio Fuel Gas Company. He has been general superintendent of production since 1951. **Frank McCament,** Mount Vernon district superintendent of production, has been named to succeed Hauck.

Also announced were promotions of three other Mount Vernon district production office employees. They are: **Alva M. Petty,** district foreman, will succeed McCament. **Cecil Dailey,** construction foreman, will become district foreman, replacing Petty. **Wayne C. Balcom,** Mt. Vernon well clean-out man, will replace Dailey.

Three Columbus area men also promoted were: **Donald C. Hubbard,** production engineer, to assistant general superintendent of production; **Richard G. Cook,** storage engineer, to assistant chief geologist; **Robert T. Patridge,** engineering and map office engineer, to assistant superintendent of the engineering and map section.

C. J. Hauck

W. C. Goodson

William C. Goodson has been promoted to technical assistant to the vice president and manager of the gas department of Republic Natural Gas Company. He previously held the position of senior reservoir engineer.

Gordon E. Hillhouse, district engineer at Corpus Christi, has been appointed administrative assistant to **R. E. Foss,** senior vice president of Sunray Mid-Continent Oil Company. **Everett L. Smith,** coordinator of training of the employee relations department, will be loaned to the production department on a temporary basis, setting up a program and supervising training during its initial stages.

L. G. Rodgers has been named manager of engineering for production. Previously, he headed the department's gas division. **R. W. Griffith,** previously manager of unitization operations, has been named manager of unitization and gas sales. He will direct a staff which is responsible for the formation of new field-wide units and will manage activities involving gas sales on a companywide basis. Completing the department's general office staff in Tulsa are **John Finch,** who continues as office manager, and **Alvin Summers,** personnel supervisor.

Lewis P. Kilbourne has been named chief geologist for Gulf Coast Leaseholds, Inc. He formerly headed the company's Louisiana offices in New Orleans.

William Yates Brown has been appointed assistant manager of Creole Petroleum Corporation's Western division in Venezuela. Brown will replace **Max Muller,** who has accepted an executive position with Esso Argentina.

Dr. Nicanor Garcia, Venezuelan geologist, has been named by Creole as manager of the La Salina district in Venezuela. The company also announced the appointment of **Duane Davis** as assistant district manager.

Dr. José Domingo Casanova, a Venezuelan petroleum engineer, has been appointed manager of the Lagunillas district in Venezuela.

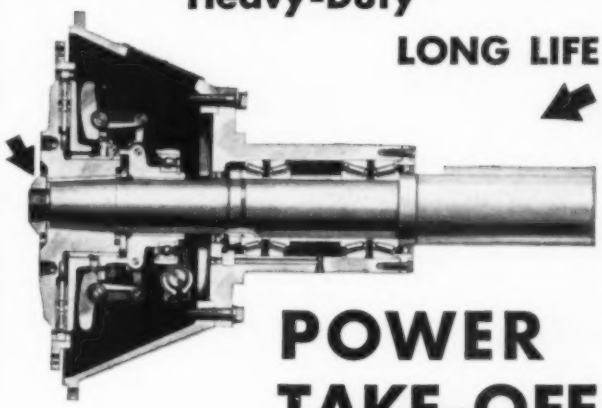
Melvin M. Tongish, petroleum engineer, has been appointed production superintendent of Eastern division in Venezuela. He replaces Casanova.

ROCKFORD

OIL FIELD TYPE

Heavy-Duty

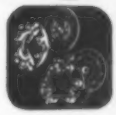
LONG LIFE



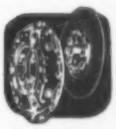
POWER TAKE-OFF

➡ Eliminates Out-Board Bearings and Couplings

The heavy-duty construction of ROCKFORD Oil-Field type POWER TAKE-OFF bearing assemblies will handle side loads that formerly required the use of out-board bearings—with hangers and flexible couplings. Shaft deflection is no problem with this extra heavy-duty power take-off—when the load is held within specifications. You can reduce the over-all length of the engine and power take-off assembly by specifying ROCKFORD.



Small Spring Loaded



Heavy Duty Spring Loaded

Oil or Dry Multiple Disc

Heavy Duty Over Center

Power Take-Offs

Speed Reducers

BW SEND FOR THIS HANDY BULLETIN

Gives dimensions, capacity tables and complete specifications. Suggests typical applications.

ROCKFORD Clutch Division BORG-WARNER

1303 Eighteenth Ave., Rockford, Ill., U.S.A.

Export Sales Borg-Warner International — 36 So. Wabash, Chicago 3, Ill.

CLUTCHES

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

What's doing in DRILLING

AAODC President Predicts 1959 Drilling Slump

Speaking before the Long Beach chapter of the American Association of Oilwell Drilling Contractors, Joe Zeppa, president of the association, expressed his belief that drilling would be down in 1959 due to several unavoidable circumstances: In general, oil company income was lower in 1958; Mid-Continent fields are going to wider spacing; because of improved technology, wells are being drilled faster. In this last connection, Zeppa stated that the drilling industry "is literally drilling itself out of business."

Warren L. Baker, AAODC executive vice president, was slightly more optimistic in his forecast, indicating that in his opinion reduction in imports might have a beneficial effect on the domestic drilling situation.

Drilling Rig Can Be Profitable Neighbor

A drilling rig can mean a half-million dollars in economic benefits to a community when it moves in and starts drilling for oil, according to A. E. Chester, vice president in charge of production for Magnolia Petroleum Company. Citing the activity of company rigs drilling near Ft. Stockton, a town of 7000 people in Pecos County, Texas, Chester said, "We will spend well over $1,000,000 drilling a wildcat well on the Kathleen J. Moore lease and Ft. Stockton people will ring up a lot of that on their cash registers."

Among the expenditures listed were a monthly payroll of $13,000, $225,000 for lease bonuses and rentals in the past eight years, $600,000 brought in by geophysical crews over the past four years, several hundred dollars in property taxes, local purchases of supplies and services, and money spent by truckers who will bring in about 870 tons of steel casing and tubing.

Contractor Sends Personnel to Argentina

Loffland Brothers Company, Tulsa, has sent a number of supervisory personnel to Argentina to direct the drilling program being done in that country for Pan-American Argentina Oil Company. Among personnel that have been assigned to that area are 13 toolpushers, 32 drillers, and a number of special services personnel. Fully staffed offices have been opened in Buenos Aires and Comodoro Rivadavia to expedite the operations. Dewey E. Williams has been appointed superintendent in charge of the Argentine operations.

Great Western Makes Safety Awards

Great Western Drilling Company of Midland has honored 56 of its rotary drillers with awards for completing a year of work without suffering a disabling accident. M. L. (Shorty) Hall of Andrews, day driller on rig No. 23, and R. L. (Bob) Hall, of Levelland, day driller on rig No. 35, received top awards for having operated their rigs five years without an accident. Their two five-man crews chalked up a total of 4000 eight-hour work days without an accident.

Tool Makes Log While Pipe Still in Hole

Sun Oil Company scientists have revealed development of a new tool which permits electric logging of freshly drilled formations while the drill pipe still is in the hole. The tool was described in a paper presented at the meeting of the Southern District, Division of Production, American Petroleum Institute, by four members of Sun's production research and development department.

Otis Engineering Company of Dallas has been licensed to construct, rent, and service the new instrument and expects to offer the tool's services commercially within the year. The device consists of a self-contained recording mechanism which is pumped down inside the drill pipe whenever a log is desired. An electrode assembly projects out through one of the mud passages of a jet bit. Logs can be recorded during the normal process of coming out of the hole, or the tool can be recovered on a wire line.

New Wildcat Scheduled In Alaska

The rig which drilled the recently abandoned Humble-Shell wildcat on the Bear Creek unit on the Alaska Peninsula will be moved westerly across the peninsula to the Bristol Bay area as soon as a road can be built. It will be used to drill a wildcat in that area for General Petroleum Corporation, which has not yet selected a site for the well.

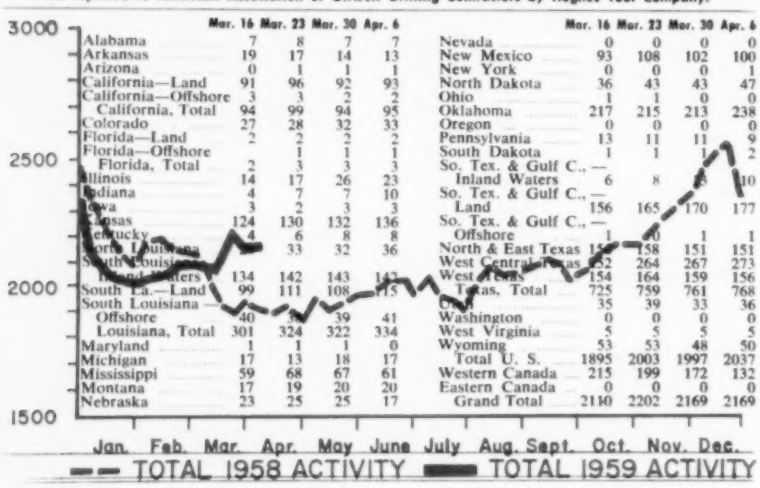
Louisiana Driller Adds Barge to Fleet

Avondale Marine Ways, Inc. was recently awarded a contract by Brewster and Bartle Drilling Company to build a new barge. The hull will be 200 ft by 54 ft by 12 ft (post type) with the working deck elevated 10 ft above the main barge deck making it possible to drill in water depths up to 16 ft. The unit will have a 140-ft mast-type derrick. Complete living quarters will be provided for the crew.

Rotary Rigs Operating in Oil Fields of United States and Canada

As reported to American Association of Oilwell Drilling Contractors by Hughes Tool Company.

	Mar. 16	Mar. 23	Mar. 30	Apr. 6
Alabama	7	8	7	7
Arkansas	19	17	14	13
Arizona	0	1	1	1
California—Land	91	96	92	93
California—Offshore	3	3	2	2
California, Total	94	99	94	95
Colorado	27	28	32	33
Florida—Land	2	2	2	2
Florida—Offshore		1	1	1
Florida, Total	2	3	3	3
Illinois	14	17	26	23
Indiana	4	7	7	10
Iowa	3	2	3	3
Kansas	124	130	132	136
Kentucky	4	6	8	8
North Louisiana		33	32	36
South Louisiana				
Inland Waters	134	142	143	142
South La.—Land	99	111	108	115
South Louisiana — Offshore	40	38	39	41
Louisiana, Total	301	324	322	334
Maryland	1	1	1	0
Michigan	17	13	18	17
Mississippi	59	68	67	61
Montana	17	19	20	20
Nebraska	23	25	25	17
Nevada	0	0	0	0
New Mexico	93	108	102	100
New York	0	0	0	1
North Dakota	36	43	43	47
Ohio	1	1	0	0
Oklahoma	217	215	213	238
Oregon	0	0	0	0
Pennsylvania	13	11	11	9
South Dakota	1	1	1	2
So. Tex. & Gulf C., — Inland Waters	6	8	8	10
So. Tex. & Gulf C., — Land	156	165	170	177
So. Tex. & Gulf C., — Offshore	1	0	1	1
North & East Texas	154	158	151	151
West Central Texas	252	264	267	273
West Texas	154	164	159	156
Texas, Total	725	759	761	768
Utah	35	39	33	36
Washington	0	0	0	0
West Virginia	5	5	5	5
Wyoming	53	53	48	50
Total U. S.	1895	2003	1997	2037
Western Canada	215	199	172	132
Eastern Canada	0	0	0	0
Grand Total	2110	2202	2169	2169



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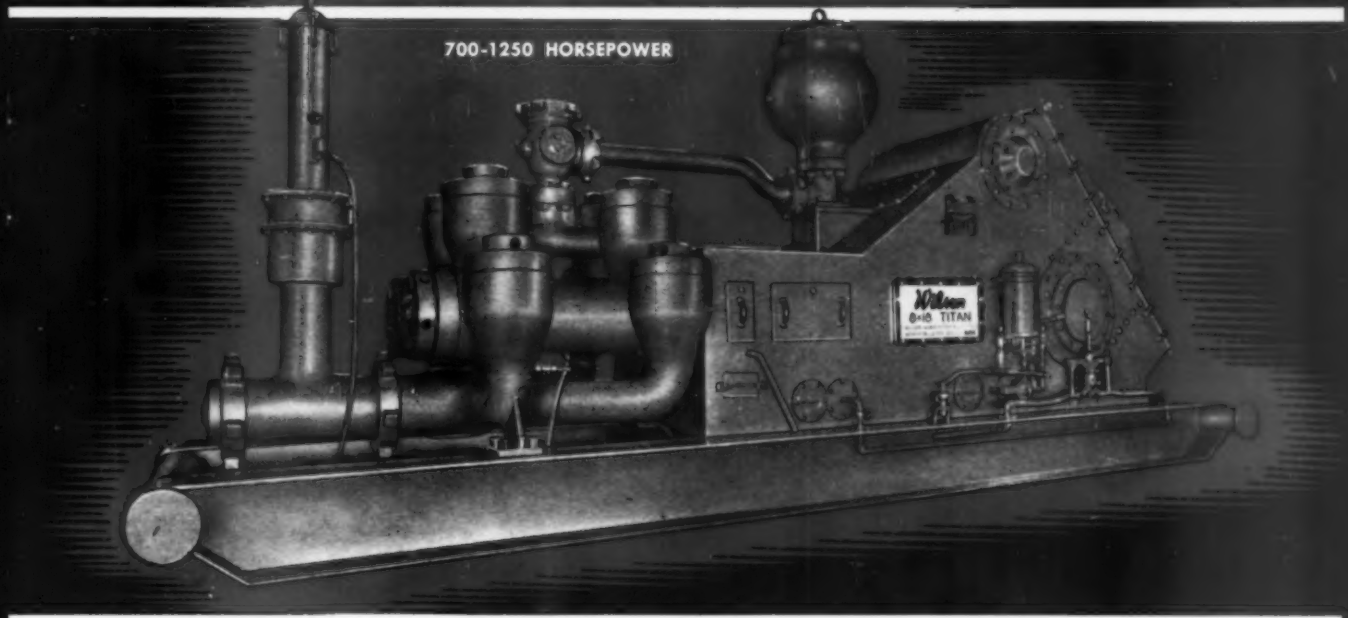

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- Less Expense for Repairs
- Less time out to change valves, pistons, rods, liners, etc.

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EXPLORATION ACTIVITIES

CANADA

Airborne Survey Over BC, NW Territories, Yukon In Progress

Spartan Air Services Ltd. has started a major airborne survey over a 24,000 square mile area north of Fort Nelson, in British Columbia, the Northwest Territories and the Yukon, using a new type nuclear magnetometer.

Three magnetometer-equipped aircraft and supporting helicopters are being used on the exploration project, which is expected to last slightly more than two months.

This new type magnetometer was originally developed in the U.S. for missile instrumentation and is now making possible faster and better surveys, it is claimed.

This device, which measures the magnetic intensity of the earth over which the aircraft flies, produces a chart showing likely areas for exploration.

The magnetometer works in conjunction with a camera carried in the aircraft which produces a continuous strip film showing the aircraft's flight path. At the same time, the magnetic intensity is recorded on punched tape which can be processed later by a computer to produce a magnetic contour map of the area covered.

Each aircraft carries a pilot and magnetometer operator. There will be two ground control stations of two men each with recording magnetometers, similar to the instruments carried in the aircraft, which will monitor changes in the magnetic background so that corrections can be applied to the airborne results. The final processing will be done at the company's headquarters in Ottawa, where the punched tape is fed into a computer and the results mapped.

Base magnetometer stations are being serviced and moved through the area by helicopters as the survey progresses.

Britalta Acquires BC Permits; To Begin Exploration Soon

Britalta Petroleums Ltd. has announced acquisition from the Province of British Columbia of 17 Crown petroleum and natural gas permits totalling 954,208 acres. The permits cover an area 70 miles long and over 20 miles wide, representing approximately 1490 square miles situated in the central portion of the province. Location of the area is about 50 miles southwest of Vanderhoof, B. C., which in turn is 69 miles by road west of Prince George, B. C.

Britalta plans to commence geological reconnaissance, geophysical work, mapping and other exploratory activities on the acreage as soon as weather permits.

The lands are located contiguously in a single block in Central British Columbia between 53° and 53° 40′ north latitude and 124° and 125° 22½′ west longitude. The nearest commercial production of oil or gas is in the vicinity of Dawson Creek, some 290 miles northeast.

Pan American Petroleum Corporation's recently acquired large block of permits in British Columbia is about 190 miles northwest of the Britalta permits, and those of Honolulu Oil Corporation are 20 miles southeast.

MISSISSIPPI

Deep Simpson County 'Cat Dually Finaled, Other Pay Seen

Completion of an important wildcat well in Simpson County has been announced by the Lion Oil Company Division of Monsanto Chemical.

The Magee No. 1 was drilled to a total depth of 14,521 ft and was dually completed from two separate sands of the Paluxy formation. On test, from perforations at 12,121-144 ft, the upper zone flowed 260 bbl of oil per day through a 10/64-in. choke. Flowing tubing pressure was 875 psi. The lower zone sand perforations at 12,174-187 ft tested 292 bbl of oil per day through a 10/64-in. choke with flowing tubing pressure of 1050 psi. Both zones produced 37.5 deg oil.

Prior to completion in these two zones of the Paluxy, a Mooringsport sand was tested and produced oil at a rate of 216 bbl per day through a ¼-in. choke.

This discovery well, located ¾-mile southwest of the town of Merritt, is on a 300-acre tract in which the company has a 50 percent interest, with Jett Drilling Company and other associates owning the remainder.

Canned Cores. The shining cans contain core samples taken from Shell Oil Company wells being drilled throughout East and South Texas. As soon as a core is removed from the well, it is sealed into one of these airtight containers and sent immediately to Shell's Houston area production laboratory for analysis. This procedure insures the core's arrival at the laboratory in the same state as when it was taken from the well. R. P. Santerre Jr., senior laboratory assistant, is recording identifying information from the cans' labels, which give well location, formation depth, etc.

So Begins The Last Chapter

The story of oil, with all its attendant theories of origin, migration, and entrapment, can be a very absorbing subject. The mere fact that oil's "life" represents a fascinating round-trip — from surface, to deposit, and back to the surface again — is material enough for many intriguing papers.

But when you pin **X** number of dollars to the end of **X** feet of drill pipe, the subject becomes considerably less glamorous.

So begins the last chapter. Payout or play-out? What are the formation's basic productive characteristics? Where are the most effective (and safest) completion points? How susceptible is the reservoir to some type of secondary recovery process?

What field methods are best suited to maintain optimum balance between the reservoir's ability and the operator's desired income? What are the most economically feasible approaches — for development, for banking?

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FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD B-143

LOUISIANA

Conoco Opens Gas-Condensate Pool in Maurice-Milton Area

Discovery of a new gas-condensate field in Vermilion Parish, about 10 miles north of Abbeville, was announced by Continental Oil Company.

On production test, the discovery well, Conoco No. 1 Clemile Savoy in the Maurice-Milton area, flowed at the daily rate of 8,000,000 cu ft of gas and 648 bbl of 46.4-deg condensate and no water from perforations at 14,675 to 14,695 ft on a 16/64-in. choke. Gas-oil ratio was 12,346 to 1, and flowing pressure was 6400 psi.

Conoco has a block of 5255 net acres in the area and owns a 50 percent interest in the well. Seaboard Oil Company and Charles Wrightsman, Houston, each own a 25 percent interest. Nearest production is one mile northwest of the discovery well.

Pan Am Stakes Marshland Test in Main Pass Area

Pan American Petroleum Corporation has staked location for an overwater rank wildcat five miles northeast of Romere Pass field in Plaquemines Parish. Pan American's State Lease 3507 No. 1, projected to 11,500 ft, is the company's initial exploratory venture in the immediate area.

Located in a deep marshland, the well site is spotted 660 ft south and 660 ft east of the northwest corner of Tract 7461 in the Main Pass area.

NEW MEXICO

Shallow Eddy County Test Promises New Penrose Pay Field

Hydrocarbon Chemicals, Inc. has successfully completed a wildcat well located in Eddy County.

The well, at 1600 ft in the Penrose formation, is producing naturally at the rate of 35 bbl of oil per day on a 320-acre lease on which the company owns an undivided 50 percent working interest. The lease allows for additional wells at 40-acre spacings. The well was drilled initially to 2300 ft and five other strata known as the Seven Rivers, Metex, Premier, Lovington, and San Andres were encountered between 1600 ft and 2300 ft. These additional formations are productive under adjoining leases and hold a good possibility of being productive from additional wells under Hydrocarbon's leases, officials say.

Trice Stakes 11,200 Ft Test Northeast of Lovington

A test of the Townsend Lime in southeast New Mexico has been staked by Trice Production Company with its No. 1 George Fisher, a projected 11,200 ft attempt to find oil three miles northeast of Lovington in central Lea County.

Trice Production Company's No. 1 George Fisher is a mile south of the Caudill field and two miles west of the Deam field. The operator has 880 acres under lease in a checkerboard spread in the area of the well site, which is spotted 1980 ft from the north line and 660 ft from the west line of Section 39, Township 15 South, Range 36.

COLOMBIA

Amkirk Spuds Test On International-Mobil Farmout

Spudding in of El Campito No. 1, a 3500-ft wildcat in the Lower Magdalena River Basin of Colombia, South America, was announced by Amkirk Petroleo Corporation, wholly-owned subsidiary of Ambassador Oil Corporation of Fort Worth.

The wildcat will test Eocene sands on a block of approximately 24,000 acres on a farmout from International Petroleum Company of Colombia, (a subsidiary of Jersey Standard), and Mobil Petroleum of Colombia.

Location of the well is two miles northwest of Barranquilla. The seismic structure is of considerable size and has high reserve potential. Closest oil production is 85 miles away.

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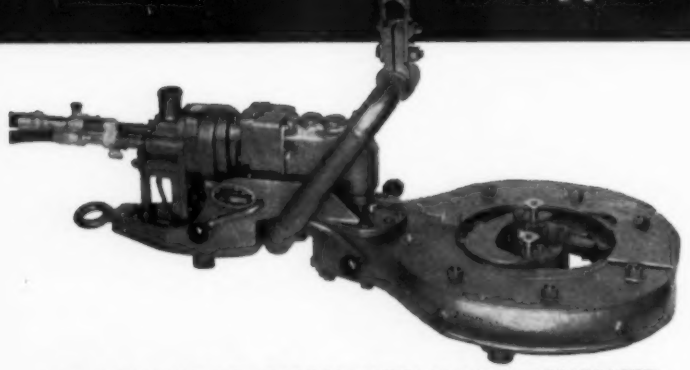

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TEXAS

Standard of Texas Finals Discovery in Basal Oil Creek

Standard Oil Company of Texas has opened a new gas-condensate field near the town of Pottsboro immediately north of the Sherman field in Grayson County. The discovery well, Mary I. McAdams 3 — No. 2, was drilled to a total depth of 12,977 ft. It is completed from the Basal Oil Creek sand through perforations from 12,813 to 12,884 ft.

On test the well established a calculated open flow potential of 75,000,000 cu ft of gas per day with 250 bbl of 51 deg condensate per million. Standard has approximately 4000 acres under lease in the vicinity of the discovery.

Lion Finds New Pay Zone In Matagorda County Test

Lion Oil Company Division of Monsanto Chemical Company has announced discovery of a new producing sand in its first development well on a 2800-acre block in the El Maton field of Matagorda County. The tract, in which Lion has a 35 percent interest, is owned jointly with Superior, Sun, and Cyprus oil companies.

The Newmont No. 1, a step-out east of the Fay No. 1 discovery well, has been completed from perforations at 10,630-10,636 ft and 10,651-10,655 ft in the Basal Frio formation. On test, the well flowed 705 bbl of 53 deg condensate, along with 4,650,000 cu ft of gas per day, through a 12/64-in. choke with 4860 psi flowing tubing pressure. The calculated open-flow potential is 40,000,000 cu ft of gas per day.

The original discovery well in this field, completed last January, produces oil and gas from formations at 10,036 and 10,120 ft. The Newmont No. 1 encountered these and two additional potential sands in the Basal Frio but were not tested, the company said.

RUSSIA

Reds Drill Deeper to Get Gas-Condensate Production

Russia has successfully completed its third "super-deep" (by Russian standards) well as Zyr on the southern tip of the Apsheron Peninsula east of Baku.

The newest producer, bottomed at over 15,000 ft, flowed 509 bbl of condensate and a maximum of 17,650,000 cu ft of gas daily. Seven other deep wells planned for depths of 5000-5200 meters (16,405-17,061 ft) are being drilled at Zyr, which is second to Karadag as Azerbaijan's largest gas field.

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equipment to produce MORE oil at LESS cost

HERCULES TYPE SOS

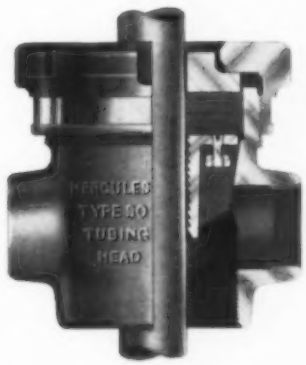
TUBING HEAD

Hercules "Type SOS" is a 4000 pound test stripper tubing head. The lower section contains the neoprene tubing stripper; the upper section or bowl contains the slips and packing arrangement. The SOS is unsurpassed for use in well servicing operations in addition to its use in flowing wells.

HERCULES TYPE SO

TUBING HEAD

Hercules "Type SO" tubing head is actually the lower section of the "Type SOS" tubing head, containing the slips and packing arrangement. It is particularly suitable for pumping due to its compactness, being approximately 12 inches high.



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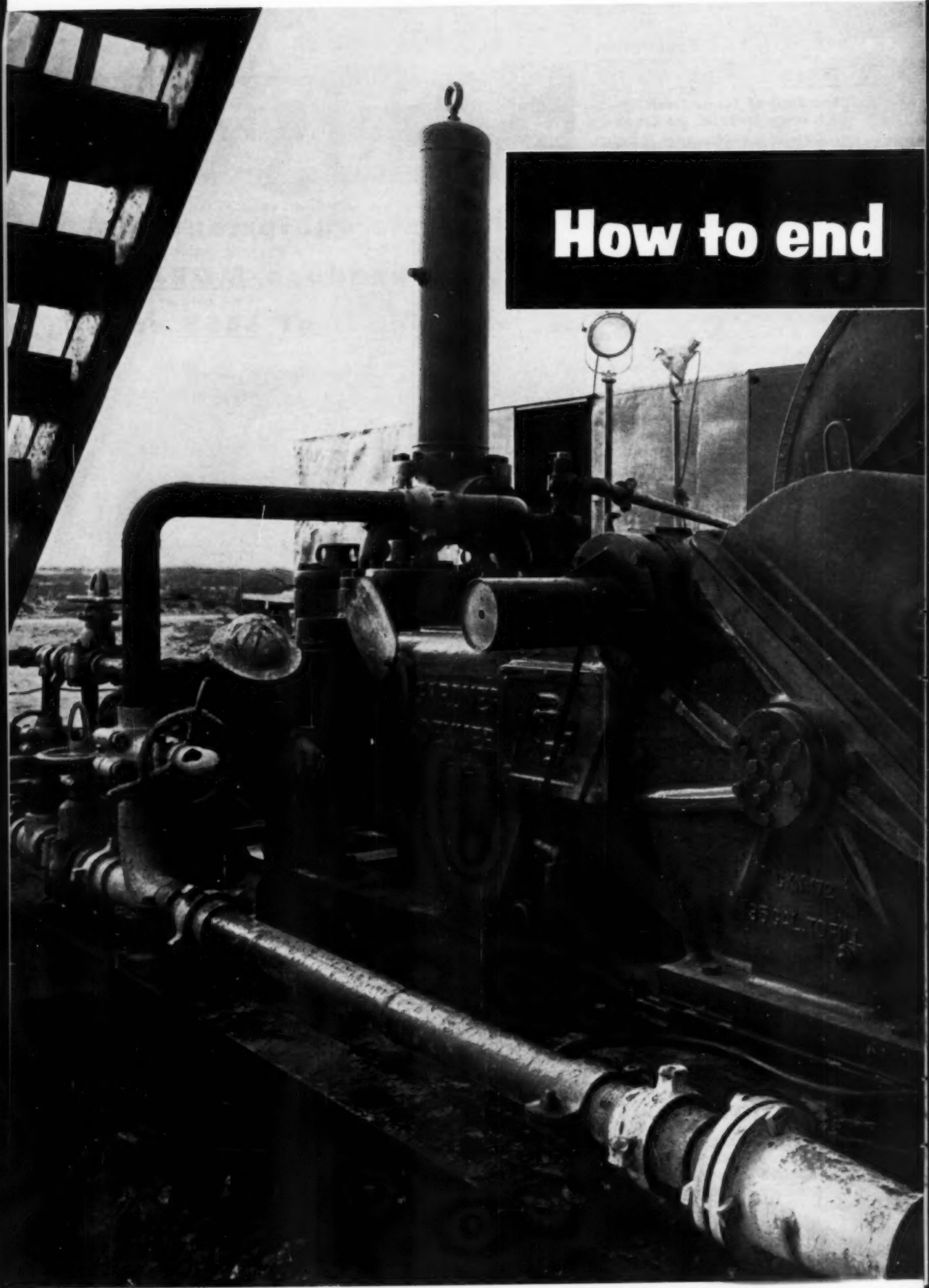
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Mud-Pump Headaches

Gardner-Denver Mud Pumps have the power, the flexibility and the **dependability** to keep a well under control. They give you a real whip hand over formation pressures and circulation problems. Their reputation as **quality leaders** is unchallenged.

All parts replacements can be made in the field. The right- and left-hand cylinders in the famous **Gardner-Denver** fluid end are interchangeable. Pressure lubrication is provided in the power end. The packed oil stop head keeps oil in, mud out. One-piece connecting rods . . . no bolts to work loose. Parts are available through your nearby J&L Supply store.

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High-Pressure Needle Valve

A high-pressure needle valve designed for pneumatic and hydraulic systems utilizes a renewable glass-filled teflon seat to assure a bubble-tight shutoff with hard to hold fluids from vacuum to 6000 psi. The valve is constructed of stainless steel with teflon "O" rings and black plastic handwheel. Complete overhaul of the valve can be accomplished without removing the valve from the line. Standard ports are female pipe NPT or female tubing AND 10050. *Dragon Engineering Company.*

Circle number (1) on reply card.

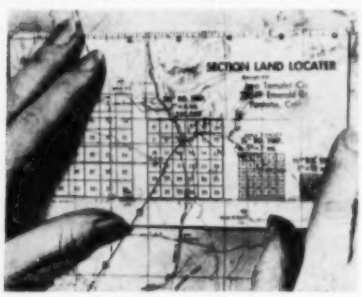
Multi-Curve Acoustic Log

Empire Geophysical has introduced a velocity logging system which gives 5 simultaneous logging records on one run. Known as the Empire VS Acoustic log, the system provides: Single receiver acoustic log; dual receiver acoustic log with 1, 2, or 3-ft spacing of receivers and switching in the hole; choice of accompanying SP or gamma-ray log; dual receiver linear velocity curve; and integrated travel time. *Empire Geophysical, Inc.*

Circle number (2) on reply card.

Section Land Locator

A new transparent plastic template instantly locates any section of land on township-drawn maps. It fits 8 most



commonly used map scales, 4 on each template. Convenient size, 3¾ in. by 6¾ in., fits pocket or ring binder. *Jero Templet Company.*

Circle number (3) on reply card.

Downhole Casing Tester

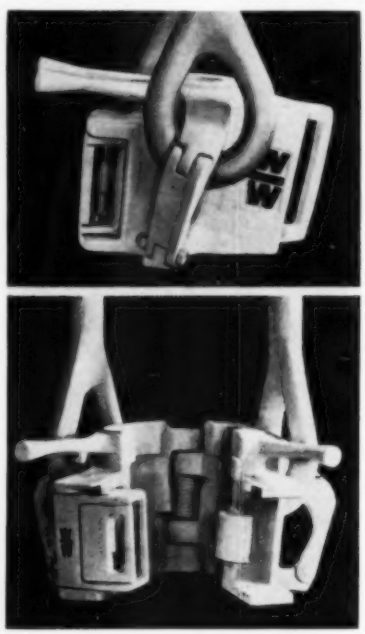
Drilling & Service, Inc. has announced a new downhole casing tester which permits detecting casing leaks and defects, under pressure, immediately before cementing. A drillable seat is made up in the bottom of the pipe. Circulation is established and the DCT tool is dropped down the pipe and into the seat to provide a positive seal. The pipe is then pressured up; a drop in pressure indicates pipe failure. The tool is retrieved with a conventional wireline overshot.

It is not necessary to wait until the entire string has been run to begin testing. The casing can be pressured up and tested at any interval. In more than 450 tests made since the first of the year, over 3 percent of the casing strings were found to be defective. *Drilling & Service, Inc.*

Circle number (4) on reply card.

Center Latch Elevators

Web Wilson's new "Champion" elevators combine new engineering concepts with modern industrial design. Link arms



and blocks are swept forward which permits compactness, yet allows more clearance for installing the links. A slanted hinge pin provides the elevator with a natural tendency to close when under load. This tendency actually amounts to several tons of force, depending upon the elevator load. A strong coil spring, located at the hinge pin, opens the elevator and forces it away from the pipe when the safety latch is released. Capacities of these elevators range from 100 to 350 tons. *Web Wilson Oil Tools, Inc.*

Circle number (5) on reply card.

Automatic Pumping Controls

Synchro-Start Products is introducing a new automatic control designed for use

on oil well and pipeline pumping. This is a program timer control for use on gas, gasoline or diesel engines. It is encased in a steel, weatherproof enclosure. The control includes standard automatic engine controls together with a timer driven by a governed d-c motor. All current is taken from the engine battery so that no commercial power is required for their operation. Many variations are available, including safety protection for all usual abnormal conditions. *Synchro-Start Products, Inc.*

Circle number (6) on reply card.

Enclosed Firing System Perforator

The new Mac-Jet perforator developed by McCullough Tool features an enclosed firing system that eliminates prima-cord exposed to the well fluid and operates efficiently under extremely high hydrostatic pressure. Each unit is fully self-contained and units are joined together to form a perforator of any required length. Standard short spacing is 4 holes per ft. 3-in. explosive spacers are available to reduce the shot density as desired. Other features include flexible construction, bottom firing, and resistance to high temperature. Mac-Jets are available in 1 11/16 in. OD and 2 1/16 in. OD sizes. *McCullough Tool Company.*

Circle number (7) on reply card.

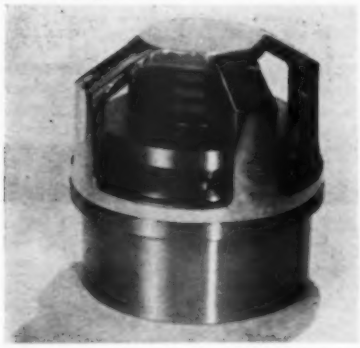
Inflatable Packer For Open-Hole Seal

A recently developed permanent type inflatable packer is used to obtain positive seal in open hole. The tool manufactured by Lynes, Inc. seals in irregular wall open hole up to twice the deflated diameter of the inflatable packer.

When the tool reaches setting depth, fluid is pumped into the steel reinforced packer element, expanding it against the well bore. After the tool has been set, a check valve keeps the packer element inflated, allowing tubing through the packer to be opened. The tool is released by rotation of the tubing string to the right to open relief slots to the packer element. *Lynes, Inc.*

Circle number (8) on reply card.

Pump Valve Moves In Straight Line

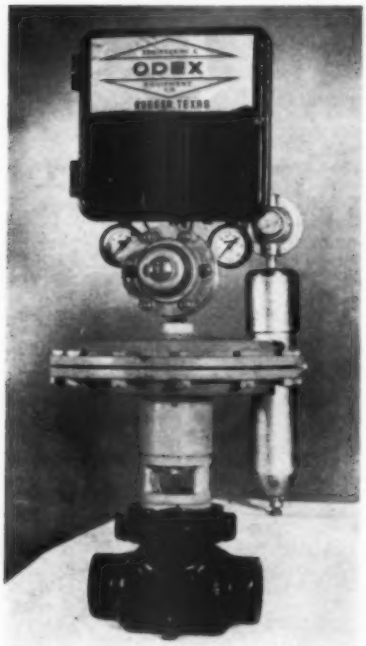


Reciprocating fluid pumps operate smooth without valve chatter with the new Dixell Tru-Lift valve. Guide features insure that the valve will move in a straight-line motion and that the valve will rotate to insure even wear. As the valve does not wobble or chatter but operates with a "soft action," fluid shocks are materially reduced with consequent reduced wear on other pump parts and on flow lines. *Dixell Development and Manufacturing Company.*

Circle number (9) on reply card.

Time-Cycle or Pressure Controller

A new wellhead safety measure is offered from Odex Engineering by unitizing a time-cycle or pressure controller with an over-pressure cutoff. Intermittent opening of the well is governed by the pressure controller, actuated by casing pressures at pre-set levels, or by a time-cycle at pre-determined intervals. The motor valve is throttled by the over-pressure cutoff and moves gradually to a full-open position with the dissipation of the gas "head." *Odex Engineering Company.*



Circle number (10) on reply card.

Rust Prevention In Cans

Introduced by Rust-Oleum, new spray-on rust preventive coatings come in 17 colors. Touch-up jobs on pipes, fittings, tools, equipment, stairs, railings, and grillwork can be done easily with the spray containers. One coat will be sufficient for most jobs, but where metal surfaces are badly rusted a coat of primer should be sprayed over the rust and followed by a finish coat. *Rust-Oleum Corporation.*

Circle number (11) on reply card.

Quadruple Valve

A quadruple valve with four 2-in. through-conduit gate valves in a single body for use on quadruple completion Christmas trees is available from W-K-M. The valve is available in the 2-in. size up to 5000 psi maximum working pressure. All multiple completion valves including the dual and the triple completion feature pressure seal bonnets, parallel expanding gates, closed packing boxes, and super finished stems. *W-K-M, divisi on of ACF Industries, Inc.*

Circle number (12) on reply card.

Aluminum Pipe Coupling

Dresser Manufacturing Division has developed a new aluminum pipe coupling, available in a range of sizes from 2 to 6-in. OD. The couplings permit up to 6 degrees pipe deflection, handle working pressures up to 150 psi, and absorb vibrations, expansion-contraction and other piping stresses. The couplings consist of a cylindrical middle ring, 2 follower rings, 2 resilient gaskets, and a set of steel track-head bolts. *Dresser Manufacturing Division, one of the Dresser Industries, Inc.*

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Fairbanks-Morse "ZC" Engines

The most dependable, most thoroughly proven engine available today for pumping service. The rugged, simple Fairbanks-Morse "ZC" is known the world over for its rock-bottom economy—its ease of starting in coldest weather—its efficiency on both gas and gasoline, with full-power switch-over to either. Clutch and sheave mount on either end of crankshaft for maximum adaptability. Six "ZC" sizes range from 3 to 30 horsepower.

Fairbanks-Morse Guarded Dripproof Motors

A completely guarded squirrel-cage induction motor with exclusive design for oil field service. Heavy-duty protected frame prevents entry of dripping liquids, flying chips or falling particles. Available with high torque, normal starting current—high slip, high starting torque—or general purpose normal torque. Ratings from ½ to 40 hp., 3600 to 600 rpm.

See your local supply store or write Fairbanks, Morse & Co., Oil Field Division, 1713 N. Market St., Dallas 2, Texas. Ask for new F-M Oil Field Equipment Bulletin.

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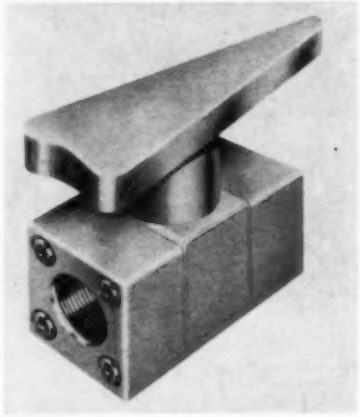
GENERATORS • SCALES • MAGNETOS • HOME WATER SYSTEMS

B-150

Quarter Turn Plug Valve

A 3000-psi plug valve with zero leakage and one quarter turn positive opening and shutoff, is announced by Hydromatics, Inc. The valve completes the positive open and shutoff cycle in a 90-deg arc of travel. Resembling an electrical panel switch, the valve handle responds



to finger tip pressure and clicks into place at both ends of the quarter turn. Position of the handle indicates whether the valve is open or closed. The valve can be used for gage shutoff and with corrosive or other hard-to-handle fluids. *Hydromatics, Inc.*

Circle number (14) on reply card.

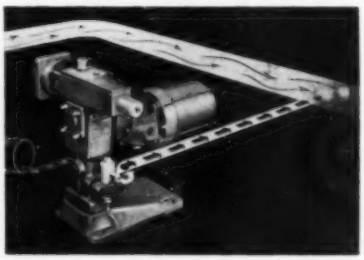
Wireline Clean Out Tool

The Greene electrically-operated wireline formation fracture tool is a new development in cleaning out wells. Cleaning action is effected by firing a combustible or explosive propellent charge into the well. The tool is engineered to operate with three charges. The first is relatively small and is freed from the tool before gases from the more powerful second and third charges are emitted into the well. The initial shock is reduced, allowing a larger combustible second charge without being too severe on the well. *Haskell M. Greene Company, Ltd.*

Circle number (15) on reply card.

Automatic Metering Pump

Hills-McCanna has introduced a compact and packless pneumatic stroke controlled meter which automatically proportions chemicals to any main line flow. Utilizing its pneumatic stroke controlled instrumentation, the pump maintains a constant discharge in proportion to the main line flow. Operating on a 3 to 15 psig air signal, the instrument



requires no additional power source of air, responds instantaneously to eliminate backflash and keep chemical-discharge-to-flow ratio precisely accurate. *Hills-McCanna Company.*

Circle number (16) on reply card.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

New Literature

Lever Operated Butterfly Valves

A new 4-page catalog describing Continental lever operated, threaded-end butterfly valves is now available. The catalog describes valves in sizes from 1 to 3 in. and contains an exploded view of the valve, tables of allowable pressure drops, dimensions and weights, plus a description of the valve and materials of construction. *Continental Equipment Company, division of Fisher Governor Company.*

Circle number (17) on reply card.

Rock Bits for Air and Water Drilling

Oil Tool Manufacturing Company has issued a completely revised catalog illustrating their entire line of HoleMaker and K-Type rock bits for both air and water drilling. Features of all bits and recommendations for use in various formations, together with drilling weights and rotary speeds are given, as well as available sizes of each design. *Oil Tool Manufacturing Company, Inc.*

Circle number (18) on reply card.

Magnetometer Survey of Western Canada

A new folder, showing the locations of 84,000 sq mi of airborne magnetometer survey coverage in western Canada, is available from Canadian Aero Service. Four survey blocks, totalling 75,000 sq mi, are available for the Province of Alberta, and 9000 in Saskatchewan. *Canadian Aero Service Ltd.*

Circle number (19) on reply card.

Electric Drive for Drilling

Advantages of electric drive are explained in a new bulletin, "General Electric Drive For Oil Well Drilling," published by General Electric. Information concerning move and rig-up time, locating equipment, drilling control, and maintenance are covered in this 16-page bulletin. Components of the drive system are briefly explained and illustrated with photographs of typical rig installations. Performance charts showing speed-horsepower and speed-torque curves are shown along with two typical electric drive rig layouts. *General Electric Company.*

Circle number (20) on reply card.

Drill Collars Booklet

A 16-page booklet published by Baash-Ross describes the manufacture and care of "Trubore" drill collars. The literature includes a section on the recommended care and maintenance of collars, specifications, weight tables, selection charts, and torque recommendations. *Baash-Ross Division of Joy Manufacturing Company.*

Circle number (21) on reply card.

Gas Lift Manual

Merla Tool has reprinted its 128-page reference manual "Gas Lift Practices and Principles." This book, with a detailed description of gas lift and its application to intermitting operations and to continuous flow operations, contains many illustrative charts and diagrams and tables of engineering data. *Merla Tool Corporation.*

Circle number (22) on reply card.

Actual case history...

OPERATOR DRILLS 170% MORE FOOTAGE, INCREASES BIT LIFE 67% WITH SEECO-MUL

That's what a division drilling engineer for a major in West Texas reported after completing a 9,700′ well with a Seeco-Mul emulsion. Oil-and-water emulsion drilling fluids are being used extensively by the division, and detailed records were maintained on both field and exploratory wells drilled with company rigs.

Not only did they get the benefit of the extreme-pressure properties in Seeco-Mul, which extended bit life, but also attributed to the Seeco-Mul system were "a more nearly gauge hole, fewer round trips, less wear on the rig and equipment, more rig time in actual drilling, and less wear on pumps, liners, and drill string." Here's what Seeco-Mul did:

- *increased bit life 67%.*
- *increased footage per bit 170%.*
- *increased penetration rate 66%.*
- *saved $9,000 in one interval.*

On another test, this one a slim-hole, "the average rate increased 45% and the footage-per-bit increased 86% in a single 800′ interval. Ten fewer bits were used, and 122 less rig hours, for an estimated savings of $7,500."

And here's what the company said about $2,540 spent for a product specifically sold for bit lubrication: "No increase in bit bearing life or penetration rate was achieved.... On the basis of the test results (higher drilling costs with no improvement in bit life), further use was discontinued until more favorable results could be anticipated to justify the added expense."

Seeco-Mul, often run in so-called soap drilling fluids to lower the surface tension, is a chemical emulsifier with superior wetting abilities. In addition, Seeco-Mul is an efficient E-P agent. It deposits an extremely tough lubricating film that will withstand high pressure and successfully reduce metal-to-metal contact of the bearing surfaces in the bit.

Seeco-Mul is making hole faster and saving money for operators from the Gulf Coast to the Permian Basin. If you would like to report similar savings in rig time — increased bit life — more footage per bit — save rig hours — ask your local mud dealer about Seeco-Mul, or write to us for technical literature and a lab sample. We'll be glad to give you full particulars without obligation.

DRILLING PERFORMANCE IN 6¼" HOLE

Well No.	H-4	D-2
Type Mud	Seeco-Mul CMC low solids	CMC low solids
Interval	9,999-10,787	9,999-10,803
Footage	788	804
Bits	8	22
Rotary Hours	126	210
Rotary and Trip Hours	174	342
Weight	35	25
RPM	38 to 50	60
Feet Per Hour	6.3	3.8
Feet Per Bit	98.5	36.5
Hours Per Bit	15.8	9.5
Penetration Rate Increase	65.8%	—
Footage Per Bit Increase	169.9%	—
Cost Per Foot*	$11.20	$22.54
Mud Cost (including mud-up)	$1,470.00	$1,150.00

*Total rig time × $45 per hour ÷ number of bits × $124.30 ÷ interval footage.

Make a good mud better...use

CROSSETT **Seeco-Mul** DRILLING MUD EMULSIFIER

Manufactured by the Chemical Division of The Crossett Company, Crossett, Arkansas

Seeco-Mul is the dried flake form of a compound of the sodium salts of abietic, linoleic, and oleic acids, together with quantities of wood tannins and lignins.

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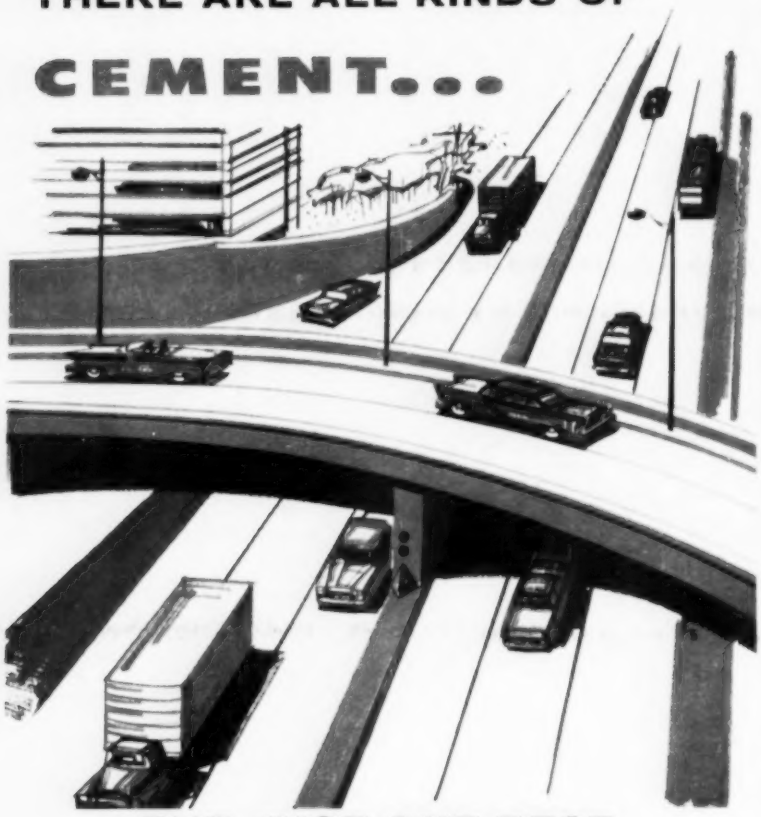
CEMENT...



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New Literature

Brochure Describes Computer System

A new brochure from the Burroughs Corporation describes the Datatron 220, an electronic computer system which links a digital computer to input-output facilities. The system can be organized as a scientific computer or as a business data processor, and is 10 to 25 times the speed of other computers in its class. It is adaptable for use with punched paper tape, punched cards, or magnetic tape. *ElectroData Division, Burroughs Corporation.*

Circle number (23) on reply card.

Adjustable Speed Drives

A new 4-page bulletin describes the operation and application of wide-range, adjustable-diameter, wedge-belt sheaves available from American Pulley. All installation and mounting dimensions are listed for both the adjustable diameter and companion sheaves. The bulletin also discusses auxiliary equipment for adjustable speed drives. *The American Pulley Company.*

Circle number (24) on reply card.

Packaged LACT Systems

Murdock Tank offers a brochure describing the components and operation of a packaged custody transfer system designed as a move-in unit on new wells, individual leases, and stripper leases. Designed to handle from 3 to 500 bbl of oil per day, the skid-mounted system has a meter tank and pipeline receiving tank, a single transfer and recirculating pump, BS&W monitor, temperature-pressure recorder, motor valves and level detectors. It is an all electric controlled unit. *Custody Transfer Systems, division of Murdock Tank and Manufacturing Company.*

Circle number (25) on reply card.

Fire Control Charts

A new 2-color wall chart which explains the 3 classes of fires and the approved portable extinguishers to be used on each has been prepared by Walter Kidde & Company, Inc. The chart shows that wet extinguishing agents like water, anti-freeze or soda-acid are suitable only for Class A fires in ordinary combustibles. Both Class B and C fires require an agent which has a smothering extinguishing action like dry chemical, carbon dioxide, or vaporizing liquid. *Walter Kidde & Company, Inc.*

Circle number (26) on reply card.

Sucker Rod Bulletin

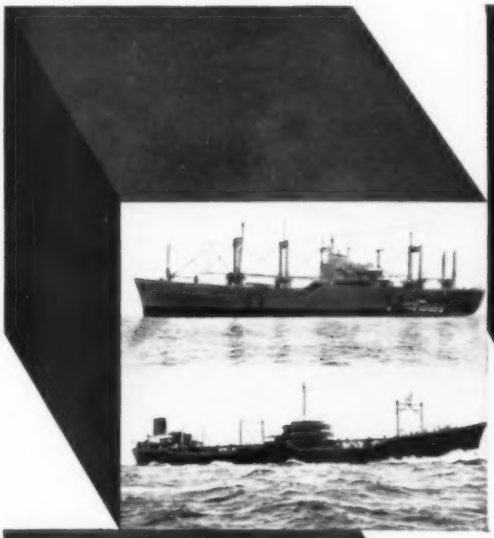
National Supply has published a new sucker rod bulletin to aid in the selection and ordering of rods. The bulletin contains information dealing with chemical and mechanical properties of available grades, and dimension and weight tables for the various rod sizes. *The National Supply Company.*

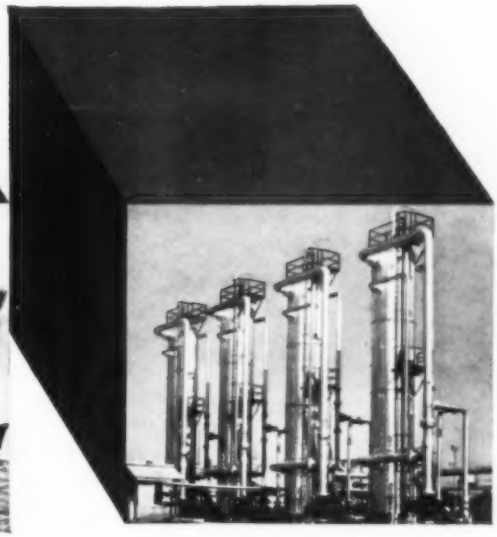
Circle number (27) on reply card.

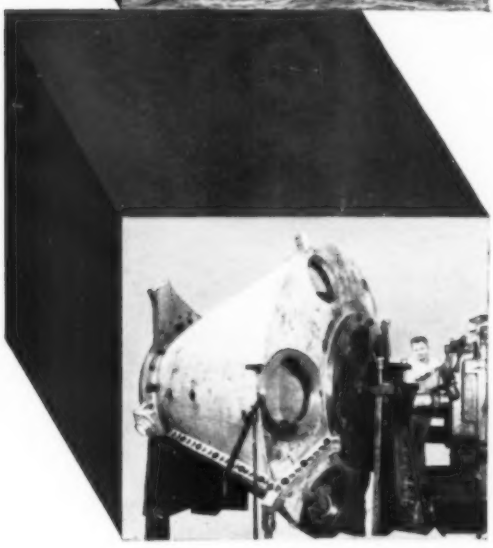
Check Valves Bulletin

Daniel Orifice Fitting Company has published a revised catalog section on piston controlled check valves. The new edition describes the patented, positive control features of Daniel check valves. Specifications and parts lists are included for 2000, 3000, and 5000 psi API flowline drilling and production valves in a wide range of sizes. *Daniel Orifice Fitting Company.*

Circle number (28) on reply card.







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HI-DRY® JEFFERSON CHEMICAL'S NEW LIQUID DESICCANT

HI-DRY® brand liquid desiccant, a new, specially prepared tetraethylene glycol concentrate, is now available to give you the extra dew point depression so often needed in dehydration of natural gas by the conventional glycol absorption process. Proved by extensive field tests, the composition of HI-DRY permits higher temperatures of reconcentration to be used without the danger of decomposition. Because of this increase in thermal stability and suitability to higher degrees of reconcentration, HI-DRY gives you greater efficiency in the dehydration of natural gas.

HI-DRY liquid desiccant is just one of a complete line of Jefferson chemicals available for sweetening and dehydration. An extensive background of experience in these processes is at your disposal. For additional information contact your local Jefferson representative, or our technical service staff at 1121 Walker Avenue, Houston 2, Texas.

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Essential Chemicals From Hydrocarbon Sources

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Three Basic Processes for . . .

MODERN GASOLINE PLANT DESIGN

1. Absorption
2. Refrigeration
3. Adsorption

Gerald D. Johnston
O. L. Olsen Company, Inc.
Houston, Texas

SELECTION of the most economical process with regard to new capital outlay is primarily contingent upon plant capacity, physical conditions of the gas stream, and the degree of product recovery desired. In addition, with today's inflationary trends, the process selected must also provide flexibility of operation and product recovery, simplicity of operation, and minimum utility requirements.

Conventional Absorption Oil Cycle Plants

The majority of gasoline plants now in operation in the United States are of the absorption oil cycle design. The schematic flow diagram in Fig. 1 shows a conventional absorption oil cycle plant. This type plant usually employs the use of a high molecular weight absorption oil, 180 or above, at near ambient temperature. The primary absorber may operate from relatively low pressures up to 2000 psi or greater.

Under many circumstances, this conventional process offers the most economical design for the modern natural gas processor's requirements. It can operate over a wide range of conditions without an adverse change in operating efficiency or process conditions. Also, this process does not lose extraction efficiency as rapidly as some when gas volumes increase or the gas liquid content decreases. When any decrease in extraction efficiency does occur, it is usually at the expense of the lighter and least valuable components. With proper design, the conventional absorption oil cycle process can also take advantage of "natural refrigeration" during the colder months of the year.

Modification of Conventional Design

A departure from the conventional oil absorption plant which has been utilized to advantage in recent years is shown schematically in Fig. 2. In this processing scheme, a rich oil deethanizer is employed in the absorption cycle rather than a reabsorber and conventional deethanizer. In addition to the advantages obtainable with the conventional absorption cycle, this modification provides the natural gas processor with efficient control of propane product vapor pressure and propane retention. This control is achieved with maximum economy of oil circulation, utility consumption, and equipment expenditure.

As shown in Fig. 2, a lean oil presaturator can be incorporated into the rich oil deethanization process to achieve further economy of operation. The deethanizer overhead vapors are contacted with the lean absorption oil after it flows from the still. In this operation additional hydrocarbons are absorbed. This results in less recycle compressor horsepower by reducing the quantity of tail gas vapors.

In certain geographical locations, the rich oil deethanization process offers another important advantage in that it allows for easy conversion at minimum capital outlay for future ethane product sales. Ethane recovery

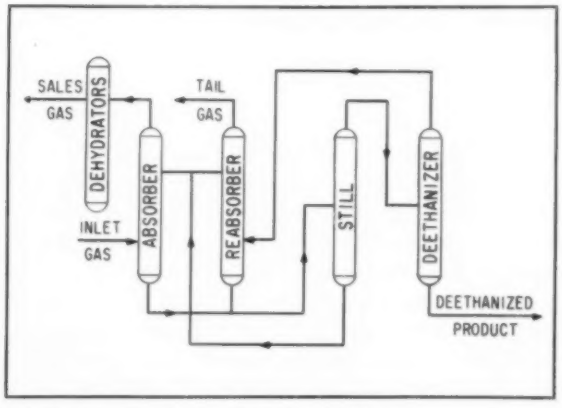


FIG. 1. Conventional absorption oil cycle plant.

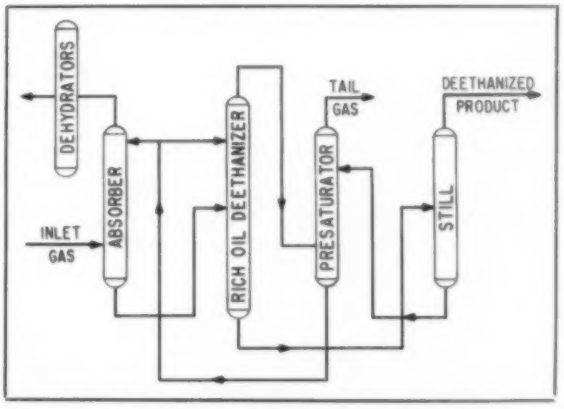


FIG. 2. Modified conventional absorption oil cycle plant.

Radioactive tracers pinpoint fuel and additive distribution

Engine equipped to measure fuel distribution and collect exhaust gas condensates from individual cylinders.

Ethyl Research shows how diet of each engine cylinder can be accurately determined

VARIATIONS in the fuel-air mixture ratio from cylinder to cylinder in a gasoline engine affect fuel economy, engine performance, and octane requirement.

This maldistribution also changes the composition of the fuel and the amount of additives received by each cylinder.

For example, one cylinder may receive a mixture with higher antiknock quality than it needs for maximum performance. At the same time another cylinder may raise the octane requirement of the whole engine by not receiving fuel of sufficient antiknock quality.

Fuel injection represents one solution to this problem. Ethyl Research now points the way to other solutions via modification of the present carburetor and tailoring of the fuel and additives.

Until recently it has been difficult to measure the portions of the fuel reaching each individual cylinder. Now accurate determinations can be made, not only of the whole fuel distribution, but also of individual components including additives.

Radioactive Tracer Techniques Provide the Key

Starting with deuterium (hydrogen-2), then carbon-14, and finally tritium (hydrogen-3), Ethyl Research tags hydrocarbon fragments of fuel and additives. Tagged components are blended into a commercial-type fuel, and their distribution is determined by measuring the radioactivity of the exhaust-gas condensate from each cylinder.

The quantity of fuel distributed to the cylinders is measured by an exhaust-gas analyzer of the catalytic-cell type.

Exhaust gas sampling is accomplished by means of an electrically controlled valve equipped with spark plug electrodes. The valve is installed in the regular spark plug hole and functions both as a high-speed (1/1,000 second) sampler and ignition source.

An electrical control system tells the valve precisely when to open during a given engine cycle.

Helpful to Both Oil and Automotive Industries

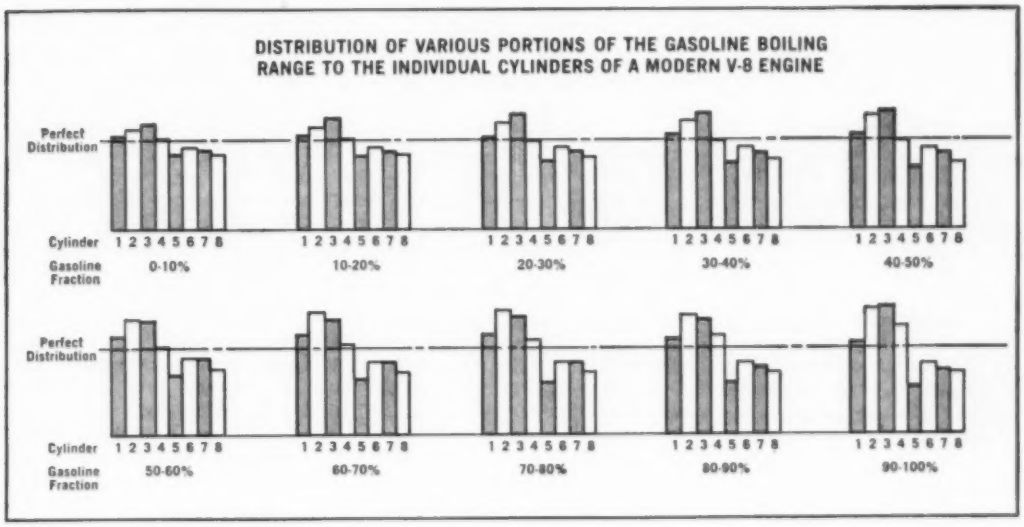
Studies such as this on the subject of fuel distribution to engine cylinders yield data which can be used by both the Petroleum and Automotive Industries in planning future fuels and engines.

A complete description of Ethyl's research on the fuel distribution problem was presented to the Society of Automotive Engineers at their National Winter Meeting in Detroit in January.

Major conclusions of this work are:

1. Uniform fuel distribution can be approached by modification of present carburetor and manifold design.

2. Antiknock quality effects brought about by poor distribution can be reduced by improved formulation of the gasoline blend.



How Ethyl Research is helping you

By exploring all facets of the fuel-engine relationship, Ethyl Research helps protect the refiner against any possible incompatibility of his fuels in the engines in which they will be used.

Ethyl Research findings are continuously made available to the refiner in technical reports, publications, and personal presentations by Ethyl Research Representatives.

Specific information about the fuel distribution problem is contained in the SAE paper entitled "Radioactive Tracers Cast New Light on Fuel Distribution." Your Ethyl Representative will be glad to see that you receive a copy upon request.

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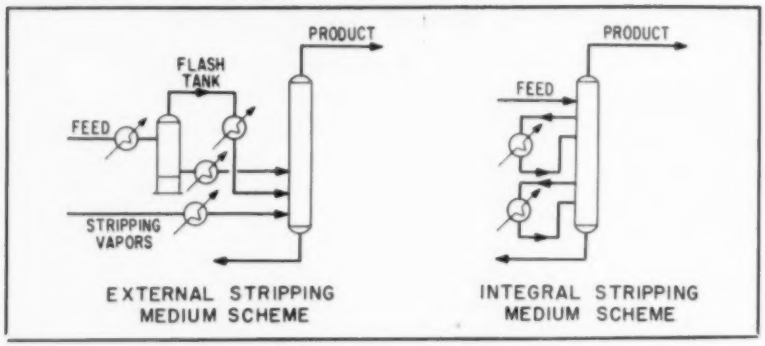


FIG. 3. Dry distillation systems.

by this process can range between 15 and 30 percent.

A great number of oil absorption gasoline plants utilize stripping steam to strip extracted hydrocarbons from the absorption oil. In this type plant a water saturated lean oil is returned to the primary absorber. In order to meet pipeline specifications, the sales gas is then dehydrated in conventional dry or liquid desiccant installations.

Dehydrated Gas Processing

Many natural gas processors are now faced with processing gas which has been dehydrated prior to entering the gathering pipeline system. Therefore, in order to maintain the dew point of the plant residue gas at a level no higher than that of the plant inlet gas, the primary absorber oil must be essentially water free. During the past few years, dry distillation schemes have proved successful in providing water free oil in conventional oil cycle plants. These systems utilize hydrocarbon vapors rather than steam as a stripping medium. Two process methods which can be used are shown in Fig. 3.

In addition, dry distillation results in elimination of steam generating facilities, reduces corrosive conditions, and has fewer freeze-up problems in cold climates.

Refrigerated Absorption Oil Cycle Plants

Conventional absorption oil cycle processes at near ambient temperatures have economical limitations with regard to propane extraction levels. In recent years, natural gas processors have steadily been increasing their propane extraction requirements from about 40 percent to above 80 percent. Also, feed gas streams are becoming leaner. Lower operating temperatures have thus become more common for gasoline plant absorption cycles.

In addition to higher propane recovery at minimum investment, the trend to refrigerated absorption plants has several other advantageous factors. At lower temperatures the absorption oil is more selective to the retention of the desired components, which usually results in a smaller amount of recycle vapors than provided by conventional plants. In order to achieve these lower temperatures without encountering undue operating problems, lower molecular weight oils have been utilized. For a given product extraction, the use of low weight oil results in less total oil circulation and an attendant reduction in equipment size. Cooling of the feed gas usually results in condensation of the heavier components, which permits a further reduction of the oil rate.

In many cases, these advantages result in the most economical plant investment and operating cost for relatively low propane recovery plants, which usually are processed by conventional oil cycle schemes. A low propane recovery refrigerated plant is shown schematically in Fig. 4.

This processing scheme refrigerates only the plant feed gas stream. This results in minimum refrigeration horsepower requirements while realizing the many advantages of low temperature absorption. Refrigeration recovery is maintained at an efficient level by heat exchange of the cold streams flowing from the absorber with the feed gas and lean absorption oil. In most instances these approaches are maintained at 10 to 20 F.

Use of low molecular weight oil also permits use of a reboiled still, reducing freeze-up problems.

Streams Suitable For Refrigeration

Although lean gas streams are readily adaptable to low temperature absorption processing, relatively low pressure, rich gas streams are economically processed in refrigerated absorption oil cycle plants. A typical plant of this type is shown in Fig. 5.

In this processing scheme a fractionating absorber has been utilized. With the proper operating conditions, this system permits the natural gas processor to absorb natural gasoline and lighter hydrocarbons from the wet gas and simultaneously strip the undesirable lighter components from the rich oil flowing from the bottom of the tower. The same control of product retention and purity is inherent in this scheme as with a conventional primary absorber and rich oil deethanizer arrangement. This process also can be readily adapted to ethane recovery. The lean oil train flow also permits the natural gas processor to achieve optimum heat economy while maintaining constant control of the lean oil composition.

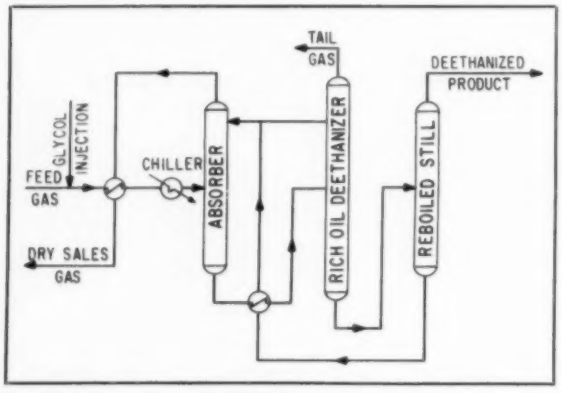


FIG. 4. Low propane recovery refrigerated plant.

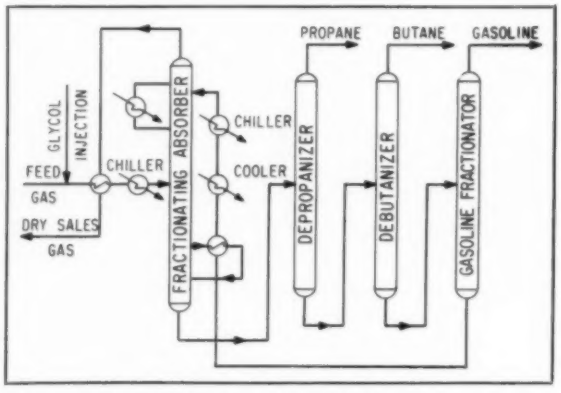


FIG. 5. Fractionating absorber refrigerated plant.

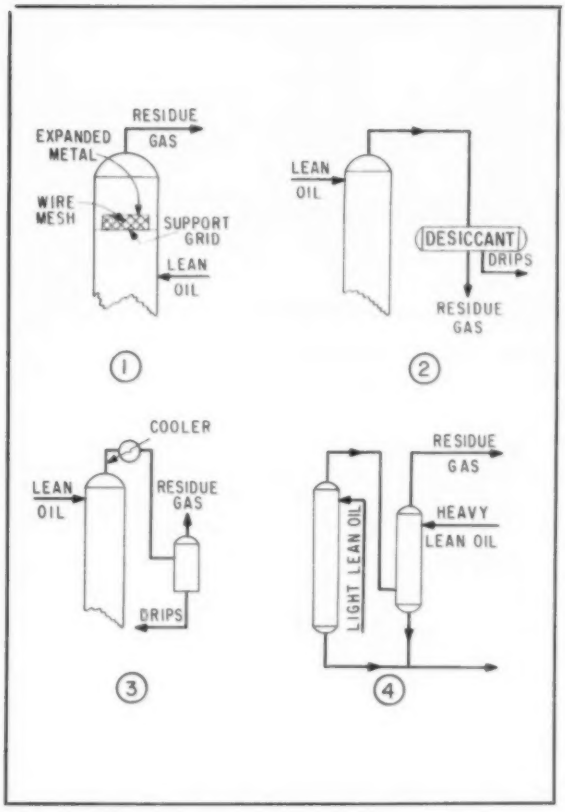


FIG. 6. Four ways to cut lean oil losses.

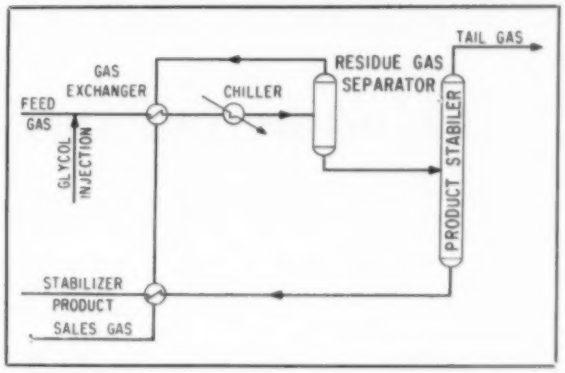


FIG. 7. Refrigerated gasoline plant.

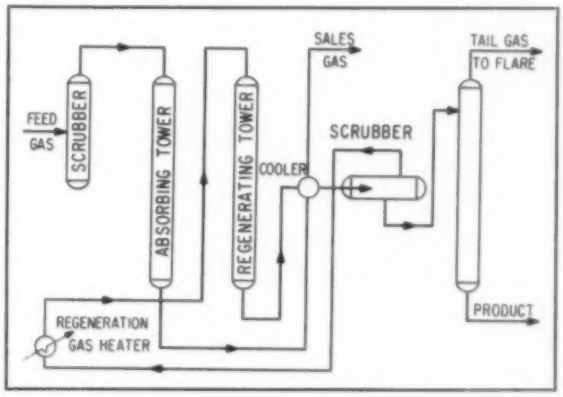


FIG. 8. Hydrocarbon recovery by adsorption.

Loss of lean oil in the residue gas increases with a decrease in molecular weight. The total quantity of this loss, as represented by pentane and heavier recovery, is a further function of the operating temperature and pressure. At lower temperature levels, less loss will occur, but at higher pressure levels more retrograde loss will result. Therefore, although lower molecular weight oils can offer economical plant investment and operating costs, the natural gas processor must make a thorough study of lean oil losses from each plant to achieve an optimum balance between pentane plus retention and absorption oil molecular weight.

Some methods commonly used to prevent lean oil losses are illustrated in Fig. 6.

Refrigerated Gasoline Plants

The recovery of LPG and heavier fractions by low temperature separation from natural gas streams has proved feasible under certain conditions. One of the largest gas processing plants in the country utilizes this type process to recover ethane and heavier components from pipeline gas. A typical refrigeration plant is shown in Fig. 7.

The low temperature refrigeration process finds most application in processing relatively rich gas streams when a complete, integrated gasoline plant is not justified. In addition, when combined with glycol injection, this processing scheme eliminates the dry bed dehydration or glycol absorption systems for pipeline specification residue gas.

Adsorption Type Gasoline Plants

The use of the adsorption process for recovery of hydrocarbons was developed in the early days of the natural gas industry. However, the adsorption process was displaced by the absorption process, due to the low recovery efficiency and high operating costs of the former.

As a result of the introduction of new adsorbent materials, a revival of the adsorption process has occurred. Present adsorption hydrocarbon recovery units now available to natural gas processors are primarily small packaged skid mounted units (Fig. 8).

In this processing scheme the feed gas stream flows alternately through two or more adsorption towers containing silica gel and/or activated carbon. The heavier hydrocarbon components and water are preferentially adsorbed from the wet gas stream.

As in conventional dry bed desiccant systems, an alternate tower is being regenerated by flowing hot regeneration gas through the adsorbent bed. This hot gas desorbs the adsorbed components, which are recovered by condensation in heat exchangers. The condensed liquid is then stabilized prior to storage.

The adsorption process is primarily applicable for processing small volume, lean gas streams which cannot be economically processed by other means. It also finds some application in installations which are required to dehydrate gas for pipeline sales and any recovery of hydrocarbons incidental to this operation can help offset the dehydration operating expense. Pentane plus recovery during the life of a silica bed installation should average about 60 percent.

Future Hydrocarbon Recovery Processes

Continual development work is being carried out by industry to further improve present day processing schemes and to develop new processing methods for the recovery of hydrocarbons from gas streams. Two process mechanisms that have appeared recently which may eventually be used in hydrocarbon recovery processing are molecular sieve and diffusion processes through membranes. ★ ★ ★

Design Economies Begin with . . .

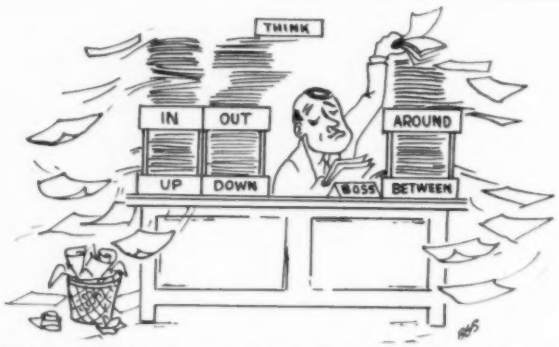
Modernization of Gasoline Plant Specifications

Save capital dollars for your company . . . use these tips to eliminate needless "gold plating"

N. C. Turner
Vice President
Hudson Engineering Company
Houston, Texas

THE OPPORTUNITIES to build gasoline plants with quick payouts are now comparatively rare. Many plants still can be built on an economically sound basis, but because of the increased cost of fuel, labor, and equipment which has not been accompanied by a proportionate increase in product prices, the builder of a modern gasoline plant must exercise considerable care in plant design to secure a satisfactory payout. To be economically sound, the modern plants must be built according to specifications consistent with maximum safety and a sound economic relationship between initial cost and operating cost. The narrow margin under which the modern plant must operate will not permit the use of "gold plating" specifications.

Unless frequently and critically reviewed and revised, mechanical specifications can become antiquated, defeating their purpose. Specifications which fail to allow for modern technological developments in equipment, and changing economic conditions, can be a serious detriment to economical design of the modern plant. **Wherever possible, specifications, standards or codes established by the industries manufacturing the various items of process equipment should be followed.** These specifications have usually been prepared after considerable collaboration between the manufacturer and user of the equipment and include the best ideas of both. The committees responsible for these codes usually meet with some regularity and are actively engaged in keeping them up-to-date and consistent with modern technological advances. Table 1 provides a list of accepted codes covering most items of equipment used in gasoline plants. Beyond the scope of these codes are some suggestions concerning various types of equipment which



Reduce detailed worry . . . simplify maintenance replacements . . . use industry standards.

Table 1. Industry specifications, standards and codes.

Pumps:
1. American Petroleum Institute Standard 610.
2. Standards of the Hydraulic Institute.

Pressure Vessels:
1. American Society of Mechanical Engineers, Section VIII, "Unfired Pressure Vessels," latest edition.
2. American Petroleum Institute, Standards for Welded Atmospheric Storage Tanks, 12C and 12F.
3. American Petroleum Institute, Standard for Design and Construction of LPG Installations — 2510.

Boilers:
1. Section I American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Latest Revision.
2. Boiler Laws, Rules and Regulations as issued by various states.

Buildings:
1. American Institute of Steel Construction Specifications.
2. American Standard Building Code Requirements Bulletin A-58.1.

Heat Exchangers:
1. American Society of Mechanical Engineers Section VIII, "Unfired Pressure Vessels."
2. Standards of Tubular Exchanger Manufacturers Association.

Instruments and Controls:
1. American Gas Association Gas Measurement Committee Report No. 3.
2. Scientific Apparatus Makers Association.

Protective Coatings:
Steel Structures Painting Council Specifications.

Pipe, Valves and Fittings:
American Standards Association Code for Pressure Piping B31.1, Code for Flanges B16.5, Code for Welding Fittings B16.9, and others as applicable.

Motors:
1. National Electrical Manufacturers Association Standards.
2. American Institute of Electrical Engineers Standards.
3. National Electrical Code Requirements.

Structural Steel:
American Institute of Steel Construction "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings."

Foundations and Concrete Structures:
1. American Concrete Institute Building Code, Requirements for Reinforced Concrete ACI 318-56.
2. Concrete Reinforcing Steel Institute Design Handbook.
3. "Manual of Standard Practice for Detailing Reinforced Concrete Structures."

Structures:
1. National Standards Association.
2. National Bureau of Standards.
3. National Safety Code.

Electrical Material:
1. National Electric Code Requirements.
2. National Electrical Manufacturers Association Specifications.

Cooling Towers:
1. Cooling Tower Institute Specifications.
2. U.S. Department of Agriculture "Wood Handbook."

might be considered when preparing a set of specifications for a specific plant. Included are suggestions of specifications which might well be omitted, as well as specifications which will give the designer sufficiently complete information to enable him to offer the most suitable piece of equipment from both first cost and maintenance viewpoints.

PUMPS

It is probably because centrifugal pumps have been so widely used for so long that voluminous and elaborate sets of pump specifications are issued by many companies. The American Petroleum Institute Standard 610 has been prepared to simplify these specifications. Other modifications to the specifications can be made in specific instances.

Stuffing Box

Consider the frequently encountered specification that the stuffing boxes shall be subject to only suction pressure. For pumps developing high differential pressures such a requirement has real merit and serves to lessen the load on the mechanical seal. For average gasoline plant pumps, such as those in reflux service, the pump differential is rather small compared to the total pressure and the use of suction pressure on the stuffing box does not lessen the load on the mechanical seal to any real extent, but because of the **unequal forces** developed on opposite sides of the impeller, the **load** on the thrust bearing may be substantially **increased.** Some specifications govern the depth of stuffing boxes of centrifugal pumps. It is not unusual to specify the depth in some fixed ratio to the shaft diameter. Specifications of this type take no consideration of the shaft speed, pressure against the stuffing box or the type of material being pumped. Since most pumps are now equipped with mechanical seals, the depth of the stuffing box is not particularly important and should be left to the discretion of the pump designer.

It is also common to see specifications requiring double row ball bearings. This is not always advisable, particularly when the double row is not of the matched type, but consists of two sets of single bearings installed as a pair. Single row bearings are sometimes definitely preferable to two rows.

Prime Movers

Frequently it is specified that the driving motor of a centrifugal pump shall be sized so that it will not be overloaded at the maximum horsepower on the pump curve. In most instances this is excellent practice, but some exceptions do arise. Occasionally, a particular pump has been selected because of NPSH requirements rather than head or volume requirements. In such cases, the horsepower at the maximum point on the curve might be several times the horsepower required at the rated load. **A smaller motor would not have been overloaded because the limiting NPSH would be reached at a liquid volume less than that required at the peak horsepower.** If pump manufacturers are required to furnish API data sheets, a fair analysis of bids will be facilitated and valuable data on pumps purchased will be available for future reference.

You can cut your investment costs by using modern specifications.

Boiler Feed Pumps

The trend in modern gasoline plant design has been to higher boiler pressures and more efficient return of steam condensate. The water to be handled by the boiler feed pump is often pure condensate. If not buffered, it is corrosive to carbon steel and iron at the pH values usually existing. For this reason, inquiries for boiler feed pumps should state in as great detail as possible, the characteristics of the feed water and its treatment so that the manufacturer may offer suitable materials to give long life.

"Gold Plating"?

Before specifying some of the more expensive factors to be incorporated in the pump design, careful consideration should be given to their real necessity for the specific pump under consideration. Are center line supports and/or water cooled stuffing boxes or bearings necessary? Must the pump disassemble from the rear? Is the possibility of increasing the plant capacity at some future date sufficiently real to specify pump casings large enough to accommodate a possible future increase in impeller diameter? Many unnecesssarily large pumps have been purchased because of unrealistic specifications in NPSH requirements. **If 15 ft of NPSH is available, a pump purchased for 6 ft can be an expensive luxury.** The usual purpose in specifying a lower than necessary NPSH is an anticipation of a change in pump service at some future time. These changes probably do not occur often enough to justify the initial additional expense.

PRESSURE VESSELS

Many sets of specifications for pressure vessels cover items not provided for in the ASME code. Some of these additional specifications may include arbitrary rules which increase the expense of fabricating the vessel with little or no return. Before including pressure vessels specifications which are more rigid than those required by the code, specific problems connected with each vessel should be considered, omitting any specification which cannot be economically justified. Where possible in the interest of economy, pressure vessel specifications should be liberalized within the limits of the code to:

1. Permit the inclusion of the corrosion allowance in the calculation of nozzle reinforcement,
2. Permit the inclusion of inside nozzle projections in the calculation of nozzle reinforcing,
3. Avoid excessive minimum thickness requirements for pressure vessels. In non-corrosive service, ¼-in. minimum thickness should be adequate for smaller vessels,

4. Permit the use of flange quality steel rather than using the blanket specification requiring fire box for all vessels,
5. Eliminate the requirement of excessive grinding to produce absolutely flush nozzles and seams inside of vessels except in the specific instances where minor irregularities inside the vessel would interfere with the assembly of vessel internals,
6. Eliminate excessive corrosion allowances on smaller nozzles as this will frequently require fabricator to use a higher flange series than that required for pressure rating,
7. Eliminate the use of ID dimensions on manways. This requirement can often force the use of the next larger size welding neck flange,
8. Include corrosion allowance only where there is a reasonable possibility of corrosion.

Bolted Internals

Some specifications require that internals, particularly trays, be bolted into the tower. In the case of heavy wall vessels, this presents no particular problem, but **installation of bolted trays in light wall vessels introduces additional fabricating expense.** These trays are usually installed in the tower when it is in a horizontal position, and because of the light wall, the cross section of the tower has assumed an elliptical shape. Before the trays can be bolted in, jacks must be used to force the tower into a circular shape so that the bolt holes in the trays and support flanges will coincide. This operation can be eliminated if tray hold down clamps rather than bolts are used.

Sieve Trays

The most economical method of fabricating sieve trays consists in punching rectangular plates with automatic multiple punches until the plate is completely covered with holes. Later the plates are cut into the required sizes and shapes to fabricate the tray. Some of the holes will be covered by support rings and other parts of the supporting structure. This, however, will not impair the operation of the tray. Sieve trays which are drawn up with blank areas adjacent to supporting members may be more aesthetic but are considerably more expensive to fabricate since the holes must be manually drilled.

BOILERS

Most specifications on steam boilers include definite requirements as to the minimum size of tubes that can be used, but as mentioned earlier in this article, most modern gasoline plants return an extremely high percentage of the steam condensate to the boilers. This fact combined with the availability of modern tube cleaners and modern methods of water treatment, have made the use of small boiler tubes entirely satisfactory. As in heat exchangers, smaller boiler tubes permit the inclusion of more heat transfer surface in a given volume and also require less metal per square foot with a net result of a more economical boiler. **The specifications of maximum heat releases in boiler furnaces should be re-examined.** Modern boiler furnaces are capable of much higher heat releases than the older types. This is made possible by improvements in the combustion characteristics of burners and the inclusion of large water wall areas which limit furnace temperatures in spite of high heat releases. Specification of large diameter drums will substantially increase the cost of a boiler, not only because of the increased amount of steel and labor required to fabricate the drum itself, but also because of additional engineering required to adapt the tube pattern to a larger drum. Larger drums do not necessarily improve the steam releasing characteristics of the boiler.

BUILDINGS

The structural design of buildings should be done with due respect to local wind and weather conditions. Buildings designed to withstand the maximum wind loads encountered in the Gulf Coast area would be unnecessarily expensive for erection in Colorado, for example. The National Standards Bureau Bulletin A-58.1 supplies adequate data on potential wind conditions in various parts of the country.

No Corrosion Allowance

The specifications of the American Institute of Steel Construction once limited the minimum thickness of all structural members to ¼-in. This restriction has been eliminated completely on inside steel structures and reduced to 3/16-in. on external structures, it being recognized that inside structures are not ordinarily subject to corrosion. In any case, increasing the thickness of structural members as a corrosion allowance is an expensive procedure since periodical painting of structural members will, for all practical purposes, completely eliminate corrosion.

Are Design Shapes Available?

The design of steel structures usually leads to the selection of various structural members from the list of sections included in steel handbooks, the selection being based on the lightest section having a suitable section modulus. Such section is considered to be the most economical. As a practical matter, **all of the sections listed in the steel handbooks are NOT READILY AVAILABLE** and some may require special rolling at premium prices. For this reason, it is better **to leave the steel fabricator some latitude** in selection of structural members so that members used may be those which are readily available. The 25 gage high tensile deep corrugated sheet commonly used today is structurally superior to the 20 gage mild steel formerly used.

HEATERS

Specifications for direct fired heaters are particularly important and deserve careful consideration since they are one of the few items of major equipment whose design is governed by no code or trade organization standards. The specifications, however, should be sufficiently broad to permit the heater designer to take full advantage of the particular type of heater in which he may specialize. For example, **it is probably better to supply** the heater manufacturer with basic **economic data** such as the value of fuel **and the required payout** time to justify an incremental capital expenditure **rather than specify** an absolute value of **heater efficiency.** This gives the heater designer an opportunity to determine the economic optimum heating surface to be included.

Watch Preheat

Another aspect to the determination of required efficiency of a direct fired heater should be given serious consideration. The efficiency of a heater is limited by the temperature of the feed to the heater; that is, the flue gas leaving the heater can in no case be colder than the coldest liquid entering the convection section of the heater. There are instances where expensive heat exchangers have been used to preheat the feed to a heater to a temperature so high that part of the **benefits** of the exchangers were **lost by the decreased efficiency of the heater.**

Pressure Drops

Specified permissible pressure drops should be as realistic as possible. The conservative specification of a low-pressure drop can be a source of expense not only because it will increase the number of passes and possibly the heating surface required, but also during startup periods, there is a tendency to run the heaters at reduced rates of flow with consequently still lower pressure drops and the attendant **hazard of coking.**

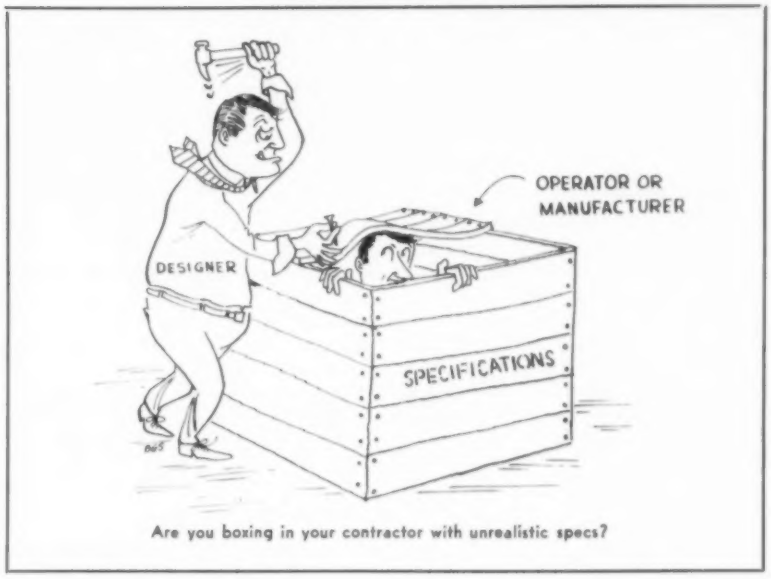
Specify Tube Wall Temperature

It is common practice to include, as part of the specifications, limiting values of the heat flux in the convection and radiant sections of the heater. In some cases, this is an attempt to prevent excessive thermal decomposition of the material in the tubes. In other instances, the purpose of limiting flux is to prevent excessive temperature and rapid deterioration of the tubes themselves. In either case, our basic objective is to limit the tube wall temperature to some acceptable value. Might it not be better to **specify maximum tube wall temperatures directly** rather than the indirect means of specifying maximum heat fluxes since the latter often fails to accomplish its objective? The measurement of heat fluxes is difficult and at best represents only average values of a given length of tube between two temperature measurement points. The maximum heat flux may be considerably larger than the average value since the heat input may vary considerably throughout the length of the tube and in the case of radiant tubes, the heat flux varies considerably throughout the circumference of the tube since the side of the tube exposed to radiant heat will of necessity be subject to higher temperatures than the shaded side. It is thus apparent that for a given service the AVERAGE heat flux may be held within an acceptable value; whereas, the MAXIMUM heat flux, and consequently the tube wall temperature of certain portions of the tube, may be **excessively high.**

A further argument for the specification of tube wall temperatures rather than heat fluxes lies in the fact that tube wall temperature is not only a function of heat flux but of transfer rate. Thus, heater tubes handling liquids at high velocities and/or high inside film transfer rates can tolerate higher heat fluxes than tubes operating under conditions leading to low transfer rates. Also, heater tubes handling fluids not subject to thermal decomposition, such as water heating or superheater service, can operate at much higher tube wall temperatures and heat fluxes than thermally sensitive fluids.

Clean Out Headers

In general, so little coking is experienced in rich oil heaters used in natural gasoline plants that **clean-out type headers on every tube cannot be economically justified.** In most cases they can be omitted entirely or a few headers may be used and located at strategic points. If clean-out type headers are used, serious consideration should be given to the **use of weld type rather than rolled-in type** since the former is somewhat less expensive and lends itself better to shop assembly. Another advantage of the use of weld type clean-out headers is that it permits the use of A-106 pipe rather than A-161 tubes since one of the primary differences between these two specifications is the tolerances in outside diameter. Since the diameter tolerance is not particularly critical in the connection of welding fittings, A-106 pipe is usually acceptable. Rolled-in type headers usually require a tube of closer outside diameter tolerances than that permitted under type A-106 so that the more expensive A-161 tubing is preferable.



Are you boxing in your contractor with unrealistic specs?

Tube Wall Thickness

It is not uncommon to see blanket specifications for furnace tubes requiring that all tubes shall be schedule 80. **In specifying tube wall thickness, due consideration should be given to the operating pressure, corrosive nature of the fluid being handled and expected tube wall temperatures.** Tubes lighter than schedule 80 may be entirely satisfactory for a given service.

HEAT EXCHANGERS

TEMA C and TEMA R

Heat exchangers represent a very substantial part of the total cost of a gasoline plant and therefore, their specifications justify considerable thought and care in their preparation. Most of the details of design are adequately covered in the Tubular Exchanger Manufacturers Association (TEMA) Code. Two somewhat different codes have been prepared by this association designated as TEMA C and TEMA R. The latter is intended primarily for refinery service and in general, incorporates more expensive construction. **TEMA C, formulated for the chemical industry, is usually entirely suitable for gasoline plant exchanger specifications.** The primary difference between the two codes concerns the specifications for corrosion allowances and flange construction. TEMA R requires ⅛-in. corrosion allowance and the use of butt welding flanges. TEMA C requires 1/16-in. corrosion allowance and permits the use of slip-on flanges. These corrosion allowances are used where no others are specified, and may be modified at the request of the purchaser after he has given consideration to the specific degree of corrosion involved.

Tubes and Tube Sheets

In setting up the specifications for heat exchangers, it is wise to consider the specific problems of each exchanger and take advantage of economies in design where such economies will not seriously affect the operation of the unit. Because more tubes can be included in a shell of given diameter, **triangular pitch tube arrangement is less expensive than square pitch tubes** and should be used where the service does not require frequent mechanical cleaning on the shell side. For a given surface, long tubes are less expensive than short tubes. More surface can be included in a given shell diameter when ¾-in. tubes are used than when 1-in. tubes are used, and ¾-in. tubes should be considered when the cleaning problem is not too serious. **Fixed tube sheets are entirely satisfactory** for clean services where temperature differences are small so that excessive stresses will not be set up in the unit due to differential expansion of the shell and tubes. In high pressure service, the cost of the unit may usually be reduced by

putting the high pressure fluid in the tube side of the exchanger so that it will not be necessary to build the shell for the high pressure. Generally, it is more economical to put the more viscous material in the shell since it will usually result in better transfer rates.

Pressure Drop

The heat exchanger designer should be allowed as much pressure drop through the unit as possible. **Where the over-all pressure drop of a system is limited, it is usually more economical to assign a large portion of the pressure drop to the more expensive exchangers and offset the pressure loss with a correspondingly low pressure drop in the cheaper parts of the system such as piping.**

Clad Tube Sheets

The use of clad tube sheets rather than solid tube sheets should be considered. Clad naval rolled tube sheets are available up to 40-in. in diameter. Below 18-in. in diameter, little if any saving can be effected by the use of clad tube sheets. Similarly, for corrosive service, the use of bimetal tubes should be considered.

U-tube bundles are more economical than floating head units since the U-tube bundle eliminates not only the floating head but the shell cover. U-tube bundles are not suitable in corrosive service where there is a reasonable expectation of periodic tube replacements.

Disengaging Space

Occasionally, reboiler specifications contain the blanket specification that the tube bundle should occupy not more than the bottom ⅔ of the shell. The disengaging space thus provided is probably more than adequate for services at higher pressures and correspondingly higher vapor densities. Where the liquid being evaporated in the shell is near atmospheric pressure or lower, more disengaging space than that provided by the ⅔ specifications may be required. This is due to the relatively low density and large volumes of vapor evolved per square foot of tube surface.

Baffles

The use of longitudinal baffles is objectionable in pulsating services such as gas coolers on the discharge of a reciprocating compressor or where the temperature differences between the inlet and outlet of the shell fluid is unusually high, and leakage across the baffle would seriously impair the heat transfer efficiency of the unit. Where these conditions do not exist, 2-pass shells with longitudinal baffles are often more economical.

Packed Floating Head

Where water is used as the cooling medium in the shell of an exchanger, consideration should be given to the use of a packed floating head since it is less expensive and will permit the use of single pass tubes, which in conjunction with a single pass shell produces true counter-current flow.

Chemical Cleaning

Many plant operators have found that chemical cleaning is more economical than mechanical cleaning, particularly when water is in the shell side of the exchangers. If chemical cleaning appears feasible, suitable nozzles should be provided for the purpose. A valve arrangement which will permit reversing the flow of water and sometimes permit removal of most debris collected in the exchanger will prolong the period of regular runs. Much of the maintenance connected with the cleaning of the water side of exchangers can be eliminated entirely by the use of air cooled exchangers. This is particularly true when the heat to be dissipated is at a temperature level substantially above the available ambient air temperature.

Gas to Gas Exchangers

There has been a marked trend in recent years to the use of low temperatures in gasoline plant processing. This type of process frequently involved the use of trains of gas to gas exchangers. When this service is clean and noncorrosive, the exchangers can more economically be made by using a series of fixed tube sheet units in which the tube sheets of adjacent units are bolted together and gas is passed from one shell to the other by means of jumpers. With this arrangement, it is necessary to supply channels only on the two extreme ends of the train.

Thermal Data

In addition to careful consideration of physical specifications of the heat exchanger, **further economies can be effected by providing the heat exchanger designer with complete thermal data.** Particularly useful in this connection is the **heat release curve** indicating the amount of heat given up by the fluid at various temperatures. In the case of condensing vapors or liquids being vaporized, **this curve can be far from a straight line.** In the absence of such information, the heat exchanger designer can only assume a straight line relationship between heat release and temperature in calculating his mean temperature differences. This assumption may result in **smaller mean temperature differences,** and consequently **larger surfaces** than are actually required.

CONTROL EQUIPMENT

Control Valves

In sending out inquiries for control valves, valve manufacturers often are furnished with the required size of the valve. It is probably more economical to supply the various valve manufacturers with complete flow data and permit the manufacturer to determine the proper valve size. There is considerable variation in the flow capacities of given sizes of valves as supplied by various manufacturers, and it is wiser to permit the manufacturer to use the smallest size valve compatible with the flow requirements since the smallest valve of adequate capacity is not only the most economical but also the most satisfactory from an operational standpoint.

Pressure Control

For low pressure service, pressure control valves are frequently specified as direct actuated rather than pilot operated valves. This is done under the assumption that for the same service a saving can be effected if the pilot is eliminated. Unfortunately, this is not always the case. Because the diaphragm of a direct actuated valve operates against a spring, it is necessary in order to obtain any degree of sensitivity to limit the diaphragm movement and consequent valve lift to a rather small value. This reduction in lift decreases substantially the capacity of a valve of a given body size so that the valve used in conjunction with a direct actuated control may of necessity be much larger in order to have the same capacity as a high lift pilot operated valve. **The increased cost of the larger valve may be much greater than the saving effected by the omission of a pilot.**

Drop Across Valve

Considerable reduction in motor valve size with a consequent saving in cost can be made by a more careful analysis of available pressure drops which the control valve must dissipate. **When high pressure drops are available,** full advantage should be taken of them in sizing the valve which will in the end result in smaller, more economical valves and better operation.

Butterfly Valves

For large, low pressure drop service, serious consideration should be given to the use of butterfly valves. While the flow characteristics of these valves are, in general, not as good as the standard motor valve, they are satisfactory for many control services particularly when equipped with valve positioners. The price differential between butterfly valves and conventional motor valves of the same capacity is substantial. ★ ★ ★

Asset or liability . . .

New Concepts of Marginal Gasoline Plant Design

Two possible plant layouts for economic production

Samuel W. Smith
Pona Engineers, Inc., Houston, Texas

ENGINEERS and constructors are continuously faced with the problem of how to turn a marginal-type gasoline plant into a sound investment.

The present trend is toward more high-efficiency plants processing gases at high propane and ethane extraction, but each year this problem becomes more pressing as it becomes more difficult to find sufficient quantities of gas to economically support a plant. Justification for these high extraction plants is the ever-increasing demand for chemical raw materials and consequent increase in value of propane and ethane.

Marginal Plants Can Pay

Smaller marginal-type gas properties have been considered, applying the latest engineering concepts and technology to determine if plants could be constructed and operated on a sound economic investment basis. Many designs have been made and evaluated for initial investment, earnings, utility and operating costs. From these studies it is believed that many of the marginal-type plants can be turned into attractive paying investments. In an endeavor to check these designs more completely and accurately, a computer program has been initiated.

Computer Programming

Problems that are generally programmed for computer solution are those recurring problems that involve long hours of tedious trial and error calculations; or that, for process or economic considerations, justify the expense involved in developing a suitable computer program.

Once a program is developed it can be used on future problems as often as required with substantial savings in man-hours and expense.

Problems dealing with design and operation of rich oil demethanizers, rich oil deethanizers and fractionators are particularly adaptable for computer solution.

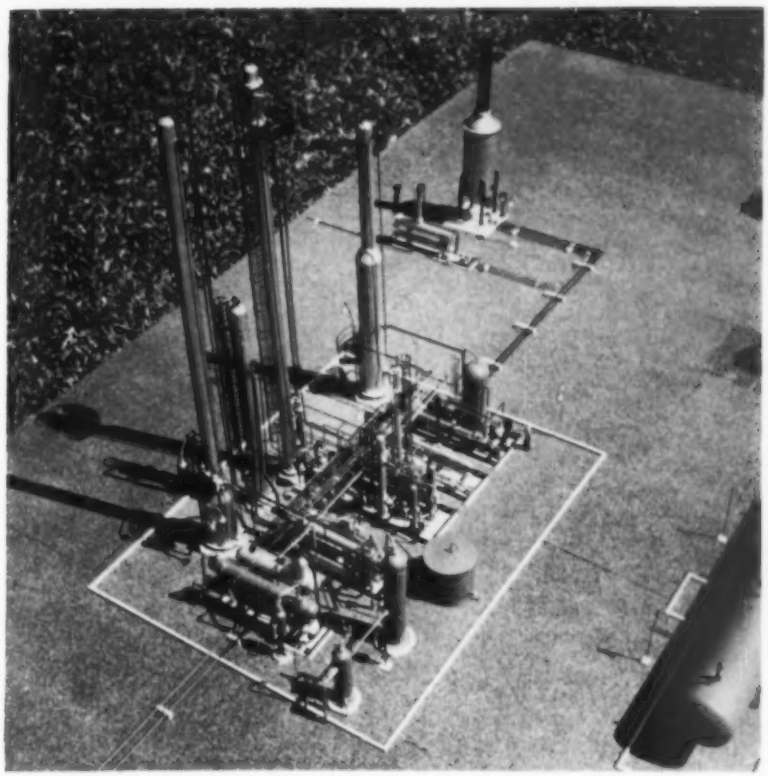


FIG. 1-

New Design Concepts

These smaller plants should be approached from new design concepts which must be carried out in the selection of equipment, materials, supplies and construction. The designer must use ingenuity in his design and prudence in the selection of the equipment to keep the cost down. It is mandatory to eliminate many of the niceties found in the larger permanent type plants, to reduce costs.

Some design features of these plants are:

1. Selection of basic process that lends itself to automation and trouble-free operation,
2. Shop prefabrication and skid mounting to minimize field, material and overall construction costs, and provide for long range salvagability of the equipment,
3. Dehydration of inlet gas streams to eliminate the problem of hydrate formation,
4. Refrigeration, required to de-

The Author

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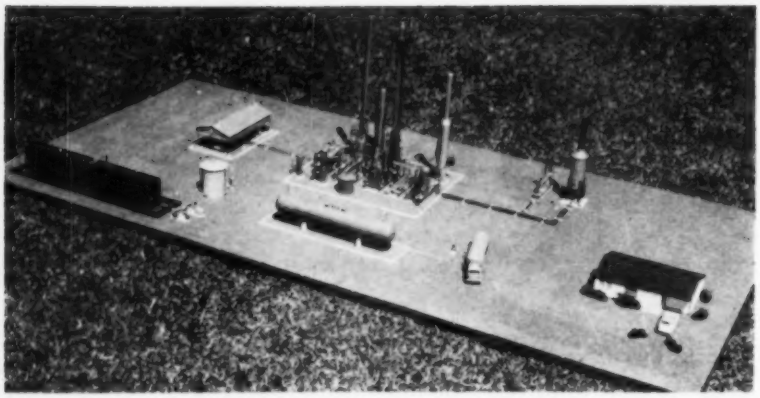

FIG. 2.

crease oil circulation and utility cost and to increase recoveries,

5. Automation as required to reduce operators to an absolute minimum. These plants can be designed for unattended operation,
6. Propane recoveries in the range of 60 to 80 percent,
7. Presaturation of lean oil with light ends, primarily methane, to reduce heat of absorption,
8. Use of low mol weight absorption oil, preferably one that can be produced from the C_7+ fraction to eliminate the expense of purchasing make-up absorption oil,
9. Utilization of high capacity trays to decrease the sizes of all fractionation equipment.

Two different plant designs will be presented to illustrate what can be done to solve some of these problems.

1.0 GPM/1000 SCFD

A scale model of a typical plant has been constructed, illustrating a plant of this type. Photographs and a process flow diagram are shown in Fig. 1, 2, and 3.

The above mentioned plant was designed to process approximately 21.5 MM std cu ft per day of natural gas, having the properties and analyses as shown in Table 1.

Table 1

	Mols/Day	GPM	Calculated Recovery (%)	Gal/Day
CO_2	436.9			
C_1	52,538.4			
C_2	2,089.7		0.56	113
C_3	903.3	0.437	70.4	6,640
IC_4	240.0	0.138	97.6	2,904
NC_4	268.3	0.149	98.8	3,167
IC_5	128.0	0.082	99.6	1,770
N_5	90.7	0.058	99.7	1,242
C_6+	199.2	0.162	100.	3,484
TOTAL	56,894.5	1.026		19,320

Design Pressure — 300 psig
Temperature — 80 F

Economics

This plant is designed to produce a deethanized product and its estimated cost would be approximately $550,000 installed. Included in this price is two day's product storage and an opera-

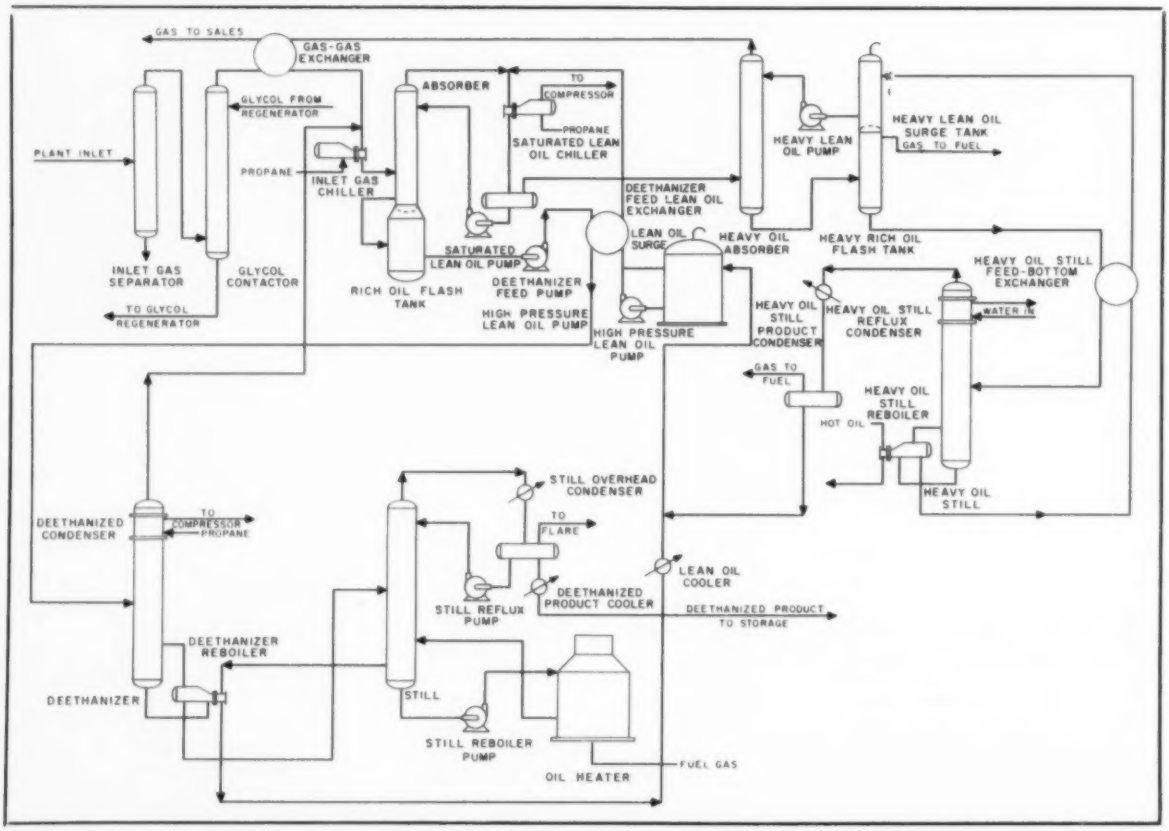

FIG. 3.

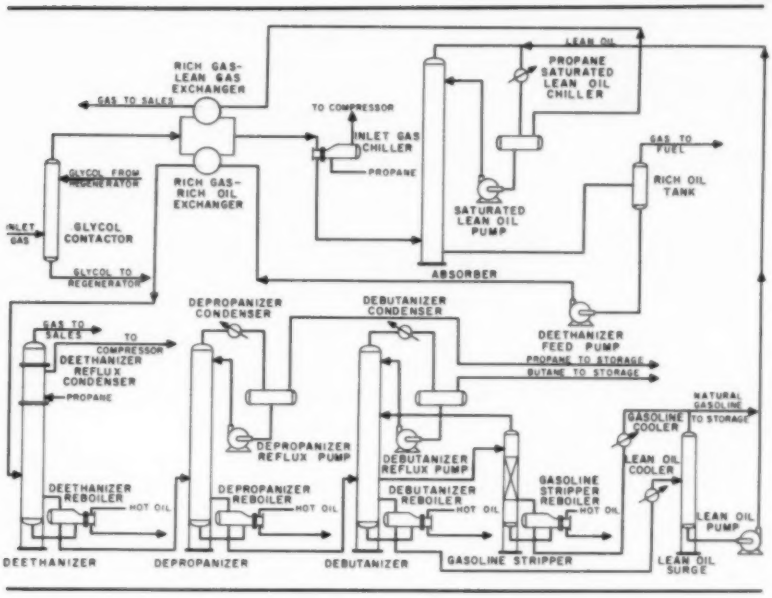

FIG. 4.

tor's house, as shown in the model photographs.

The utility requirements are estimated to be:

Fuel gas	369 Mscfd
Water make-up	30 gal/min
Electricity	2000 kwh/day

Other major expense items are:

Product shrinkage	593 Mscfd
Labor: $/year—360 Days	
Operator 8hr/day—$3/hr	$8,640
Pumper 8 hr/day—$2/hr	5,760
Maintenance materials & labor (4.75 percent of $550,000) per year	$26,125
Taxes and Insurance (0.45 percent of $550,000) per year	2,475
Depreciation (basis full value over 12.5 years)	44,000

Table 2

	Mols/Day	GPM	Calculated Recovery (%)	Gal/Day
N_2	286.3			
CO_2	21.1			
C_1	7,506.6			
C_2	2,142.5		1.4	290
C_3	1,844.3	3.851	83.0	15,979
IC_4	310.0	0.769	98.2	3,775
NC_4	637.2	1.522	99.1	7,546
IC_5	125.3	0.348	99.8	1,735
NC_5	191.3	0.526	99.8	2,623
C_6	108.2	0.337	99.9	1,685
C_{7+}	19.8	0.077	85.9*	330
TOTAL	13,192.6	7.430		33,963

Design Pressure — 500 psig
Inlet Gas Temperature — 130 F

*The reason for the apparent low recovery of C_{7+} is due to the fact that this fraction is used as lean oil and the lean oil loss was taken into account. No outside make-up lean oil is required.

7.4 GPM/1000 SCFD

Another plant of similar design is currently under construction. A flow sheet of this plant is shown in Fig. 4. This plant was designed to pass 10 MM std cu ft per day of natural gas through the absorption and gas processing section of the plant. The liquid handling capacity of this plant is based on the products recovered from 5 MM std cu ft per day of natural gas, having the composition shown in Table 2.

Economics

It is estimated that the cost of the battery limits plant as shown on the flow sheet in Fig. 4 would be $350,000. This price includes 5 days storage for all products. The utility requirements are estimated to be:

Total fuel gas	213 Mscfd
Water make-up	19 gpm
Electricity	(Fuel gas to drive generator included in total fuel gas. No charge made for electricity except fuel gas.)

Other major expense items are:

Product shrinkage	1.113 MM scfd	
Labor:		$/Year 360 Days
Operator	8 hr/day, $3/hr	$ 8,640
Pumper	8 hr/day, $2/hr	5,760
Maintenance materials and labor (basis 4.75 percent of $350,000)		16,625
Taxes and insurance (Basis 0.45 percent of $350,000)		1,575
Depreciation (basis full value over 12.5 years)		28,000

This plant is designed to produce 95 percent pure propane and butane as set out by NGAA specifications. The natural gasoline is to have a vapor pressure of approximately 12 lb Reid vapor pressure.

To obtain the most efficient operation at the lowest initial investment, each plant should be individually designed for the gas available for processing.

Relocation Possible

Skidmounting and prefabrication permit economical relocation of plants of this type. If a move is planned, re-engineering is desirable to maintain high extraction efficiency and product recovery. Necessary re-engineering can be completed and revamp work, if required, should be planned, if possible, before the operating plant is shut down. Plants of this type are relatively easy to revamp, dismantle and re-erect because the skids are portable and the equipment is relatively small.

Automation

The economic feasibility of these smaller plants is frequently overlooked because they are compared with the larger type plants, both from the standpoint of initial investment and operating expense. Since these plants are of marginal size they should be designed for partial attendance during normal operation. This unattended operation is accomplished by complete instrumentation and an adequate alarm and shutdown system.

Efficiency

Plants of this type should be designed for high propane recovery, minimum heat input, and minimum refrigeration requirements. A carefully designed heat exchange system will reduce these requirements. To promote efficiency a low molecular weight lean oil is used where possible. Make up lean oil can be eliminated in many cases by producing lean oil from the heptanes plus fraction of the gas.

Minimize Investment

One of the most effective ways to insure an attractive economic picture for a marginal plant is to minimize the initial investment. In designing plants of this type, all unnecessary equipment and materials must be eliminated. Ways to reduce initial investments are mentioned in the design features above. The most important ones are selection of the proper basic process, shop prefabrication and skid mounting, use of high capacity trays in all towers and the use of a low molecular weight lean oil.

The plant designs as presented above may encourage producers to take another look at some of their old analyses with the realization that a small, modern, efficient plant could be a sound investment. ★ ★ ★

Natural Gasoline In Motor Fuel . . . What Is Its Future?

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NO ONE NEEDS to be reminded that in this business one can't look very far into the future without a reliable crystal ball. Since these aren't readily available, about the best that can be done is to analyze past and present situations, study the trends, throw in a little educated guess work and try to come up with an accurate forecast.

It is along these lines, that the utilization of natural gas liquids in motor fuel will be discussed: first, to review the present situation . . . where we stand today; next, to look at the trends and hazard a forecast on the future of natural gasoline in motor fuel.

Springboard

In order to provide a convenient framework for a review of current practices and a springboard for some predictions, this discussion is based on the operations of the average refinery in Oklahoma, Kansas, and Missouri and the Texas Panhandle. In this area the percentage of natural gasoline liquids blended into refinery gasoline is about the same as the national average.

Average Refinery

Fig. 1 shows a simplified flow diagram of the average refinery today. Notice that only the major gasoline producing units are shown. These are the individual streams which make up the gasoline pool: Light gasoline from the crude unit – C_5 to about 260 F end point; reformate from the catalytic reformer – C_5 to 400 F; light and heavy gasoline from the catalytic cracking unit which boils from C_5 to 430-440 EP; and, finally, the thermal gasolines which boil between C_5 and 375 F. These streams, along with butane and natural gasoline, will be blended into finished premium and regular gasoline blends which meet all motor fuel quality requirements.

Product Quality

Fig. 2 shows some of the quality requirements which a refiner must consider in putting finished gasoline together. It is convenient to break these requirements into three categories, although in practice many of the items are interrelated. Excessive carbon

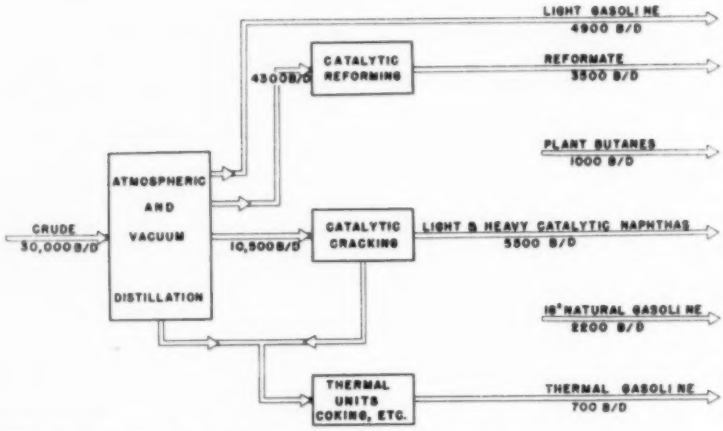

FIG. 1. Simplified flow diagram "average" refinery today's operations.

QUALITY	SPECIFICATION OR CONTROL
FREEDOM FROM KNOCK	RESEARCH OCTANE NUMBER MOTOR OCTANE NUMBER SENSITIVITY
PROPER VOLATILITY	FRONT END VOLATILITY – RVP & 10% POINT MID FILL – 50% POINT BACK END VOLATILITY – 90% POINT
ENGINE CLEANLINESS & CUSTOMER ACCEPTANCE	SULFUR STABILITY CORROSION CARBON FORMATION ODOR COLOR

FIG. 2. Motor fuel quality requirements.

Adapted from a paper presented by the author to the Panhandle-Plains regional meeting of the Natural Gasoline Association of America. Permission of the NGAA to publish this paper is gratefully acknowledged.

buildup, for example, increases the octane requirement.

Going down the line: Research octane number indicates the tendency of a gasoline to knock at low speed, full load conditions. Motor octane measures the tendency to knock at high speed. Sensitivity is the difference between the two. Motor octane ratings are becoming more and more important — primarily because of the increased use of automatic transmissions.

Proper front end volatility is required for start-up and vapor lock control. It must be high enough for easy starting, but not too high to give a tendency to vapor lock. Proper middle violatilities are important for rapid engine warm-up. Back end volatilities must be controlled to minimize crank case dilution and carbon formation.

STREAM	VOLUME B/D	RVP	APPROXIMATE QUALITIES: RESEARCH OCTANE 2.9cc's TEL	BOILING RANGE °F (VOLATILITIES) 0 100 200 300 400 600
LIGHT GASOLINE	4,900	7.4	80.1	
REFORMATE (93 clear)	3,500	4.0	99.9	
LIGHT CAT NAPHTHA	4,400	8.3	98.8	
HEAVY CAT NAPHTHA	1,100	0.5	93.8	
THERMAL GASOLINE	700	6.5	85.6	
BASE POOL	14,600	6.3	92.8	
18° NATURAL GASOLINE	2,200	20.2	89.0	
PLANT BUTANES	1,000	60.0	104.6	
FINISHED POOL	17,800	11.0	93.0	
POOL BASED ON	25%	99	OCTANE PREMIUM	
	75%	91	OCTANE REGULAR	

FIG. 3. Typical gasoline pool average refinery today's operations.

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The last items — sulfur, stability, corrosion, odor, and color — are all important to assure the dependability and marketability of the product. In the final analysis, of course, it is the customer, the motoring public, who must be satisfied; this is the reason for the stringent quality control which must be exercised.

Gasoline Pool

The various gasoline streams are shown together in a pool in Fig. 3. It's easier to see the relationships of the variables on a pool basis although in practice, of course, these streams would be blended into two or more separate grades of gasoline. This sometimes is a ticklish job because stocks with the required octane characteristics do not always have the proper distillation characteristics, but assume here that it can be done. In the gasoline pool shown here, the goal is 25/75 premium-regular ratio. Octanes needed are 99 and 91 of premium and regular. These are about average figures for the Midwest. On this basis, then, the pool octane required is 93.

Notice that the reformate stream in the base pool is the only stock available with high enough octane to meet or exceed premium gasoline requirements. More will be said later about operation of the catalytic reformer and its effect on natural gasoline utilization.

To make finished gasoline out of the base pool, three things must be done: The gasoline boiling range must be extended forward; the vapor pressure, which to some degree is a measure of the amount of "extension," must be raised from 6.3 to 11.0 lb; and the octane must be raised to 93. This is accomplished by the addition of natural gasoline and plant butanes.

In this hypothetical pool, an attempt is made to use the maximum possible volume of plant butanes. With no alkylation the plant will have around 1900 bbl per day excess butanes. This case uses 1000 bbl per day in motor gasoline which leaves about 900 bbl per day to burn in the plant furnaces or dispose of in other ways.

The natural gasoline used in the pool is 12 percent of the total. This is about 2 to 3 percent higher than average for the area, and results from using a higher than average TEL level for the pool. A 2.9 cc per gal lead level, which is maximum, was used to standardize and simplify the calculations; average for the area is around 2.5 cc per gal. Now, with a finished gasoline pool blended (Fig. 3), the refiner is set until he is forced to raise octanes again.

Reforming

Without additional processing equipment, octanes can be added to the gasoline pool in two ways. First, feed rate to the reformer will be increased by lowering the initial boiling point of the reformer feed. In effect, this will reduce the volume of light straight run gasoline. Then, when unit feed limitations have been reached, or when it is no longer attractive to reform the relatively high octane light straight run gasoline, reformate octanes will be raised by increasing the severity of the reforming operation. However, this can only be done at the sacrifice of total gasoline volume.

To understand the reason for this refer to Fig. 4 which shows a typical

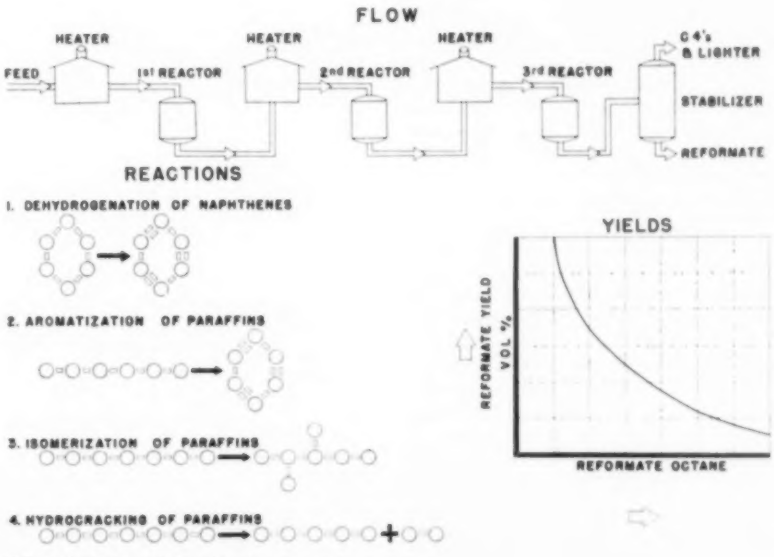

FIG. 4. Typical catalytic reforming operation.

catalytic reformer operation. This unit can upgrade octane number from 40 to 60 points, and is highly flexible. Heavy naphtha boiling anywhere between 200 and 400 F is charged to the preheater. Hot feed is then charged to the first of three platinum catalyst filled reactors. The first three of these reactions — dehydrogenation, aromatization, and isomerization — absorb heat. The charge must therefore be reheated in the second heater to promote further reaction. The fourth reaction — hydrocracking — takes place primarily in the third reactor; and it is here, through the mechanism of destroying the lower octane components by making gas, that the greatest yield loss takes place. Thus, as product octane is increased, by increasing the severity of the operation, product yield is decreased. This is demonstrated on the yield curve in Fig. 4.

STREAM	BARRELS PER DAY 1958	BARRELS PER DAY 1962	RESEARCH OCTANE NUMBER 1958	RESEARCH OCTANE NUMBER 1962
BASE POOL	14,600	14,200	92.8	94.9
18° NATURAL GASOLINE	2,200	1,800		
PLANT BUTANES	1,000	900		
FINISHED POOL	17,800	16,900	93.0	94.8
REFORMATE FEED	4,300	5,800		
REFORMATE OCTANE, CLEAR			93.0	95.0
REFORMATE YIELD %	81.0	78.0		

FIG. 5. Comparison of 1958 and 1962 gasoline pools average refinery.

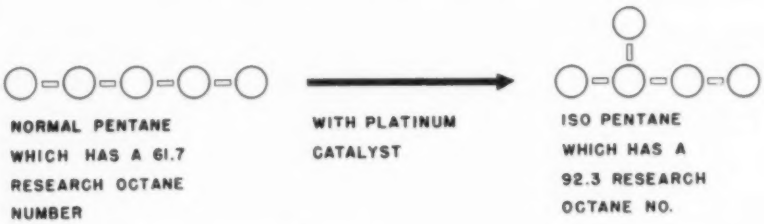

FIG. 6. Simplified pentane isomerization reaction.

Additional Processing

Sometime down the road the refiner will no longer have ability to increase octanes by increasing reformer feed rate and reformate octane. The economical product octane level varies widely, but the maximum will probably level out somewhere around 95 octane clear. Above this point yields and catalyst life deteriorate rapidly. This hypothetical refinery will reach the maximum reformer feed rate of 5600 bbl per day and product octane about 1962. At this level, yield has dropped to around 78 percent. This would happen sooner, however, if crude runs or premium percentage were increased or a greater volume of natural gasoline utilized, or if octanes increased faster than predicted. Fig. 5 shows a comparison of 1958 and 1962 gasoline pools. Notice that total gasoline volume is off by 900 bbl per day. This results from chewing up naphtha with the reformer, using less natural because of the higher octane requirement and using less butane because of a slightly higher vapor pressure pool. The latter is beginning to hurt because the refiner is now burning over 1000 bbl per day of butanes.

At this point, in the face of continuing increases in octane requirements, the refiner has three choices. The first is to continue to back natural gasoline from the gasoline pool and maintain a constant percentage of premium gasoline. This would result in a drop in total gasoline volume. The second choice is to hold natural gasoline constant and decrease the percentage of premium gasoline. Any decision on either of these two choices would involve, of course, a detailed consideration of natural gasoline costs, the cost of reforming at high severity, and the economics of producing premium gasoline. There is no doubt but that most refiners in this situation will seriously consider backing out the highest cost increments of natural gasoline. Neither of these choices, or even some combination of the two, is particularly desirable or even possible for a long period of time if gasoline volume is to be held constant. The third choice is, of course, to add additional processing equipment.

Alkylation

For the average refinery there is no doubt that alkylation should be the next processing step, assuming that all potential reformer feed is being reformed. (For many refiners, economics will have dictated this sooner.) There are several reasons for this: Much of the potential feed stock is being burned; alkylate is a fine, high octane blending stock; and finally, alkylate will reduce the increasing sensitivity of the gasoline pool by increasing its motor octane rating. The refiner will probably find it economical to alkylate both butylenes and propylenes.

With this newest addition to the processing scheme in the hypothetical plant, the refiner is back in business. He can bring natural gasoline back into the pool, and ease off on reforming severity. Both of these steps will increase total gasoline volume. Moreover, with the high vapor pressure isobutanes and butylenes out of the gasoline pool, along with the increase in pool octanes from the alkylate, it will be possible to utilize even more natural gasoline than before.

Up to the point where the plant is reforming all possible feed and has added an alkylation unit, fairly specific terms can be used. Beyond that point, the picture in the crystal ball gets a little fuzzy and it is necessary to look more at trends and the overall outlook. At any rate, with time and continued increases in octanes, the refiner will find his back to the wall again. He will be back up to maximum on reformer severity and feed; he will have decreased the use of natural gasoline as far as can be afforded; so again the addition of another processing step is indicated. The cycle has essentially repeated itself.

Isomerization

The next logical step is pentane isomerization. On the average, this step will come far down the line, so that no particular attempt has been made to decide when the average refinery might resort to this scheme. However, in certain isolated examples, the process is attractive to some refiners today. Some units are in operation at present. There is one very significant fact connected with the installation of this unit: The role of natural gasoline has changed from that of being strictly a blending stock to that of being, partially at least, a process unit feed stock.

A simplified molecular diagram for

this reaction is shown in Fig. 6. The big incentive for this process is demonstrated here. Note that the iso-pentane product is over 30 octanes higher than the normal pentane feed.

Isomerization-Dehydrogenation

Eventually, if octanes continue to rise, the pentane isomerization unit will be insufficient to supply pool octanes. Thus, the cycle will have come full circle and the refiner will again be ready for a new upgrading scheme. This time, a butane dehydrogenation—butane isomerization — alkylation package might be the answer. Here again, as in the case of the pentane isomerization, natural gasoline — actually the butanes in natural along with additional field butanes — will become a feed stock. In practice, the feasibility and timing of this process would vary from refinery to refinery since the economics depend primarily on a large supply of reasonably priced butanes. Assume here that the average refinery found this an attractive proposition. Although in reality it's doubtful that many 30,000 bbl per day refineries will be able to utilize any of the processing schemes available today.

Fig. 7 gives an indication of how much refinery face lifting may be required between now and several years hence. Five new major process units have been added . . . alkylation, pentane isomerization, butane dehydrogenation, butane isomerization, and a second alkylation unit (or expanded existing unit). This would require an investment of more than $10 million, but it is now possible to make a gasoline pool with a research octane considerably above 100.

It should be stressed that the sequence and type of process unit additions suggested here is only one possibility. This particular process unit lineup does, however, make three points evident: First, the magnitude of the change that refiners may be required to make; second, higher octane production will be possible; third, utilization of natural gas liquids should not be materially effected by continued increases in octane requirements.

Graphic Summary

This whole situation has been summarized diagrammatically in Fig. 8. This shows a plot of natural gasoline utilization versus time. This chart has no particular scale since it only serves to indicate a trend. Notice, though, that natural gasoline utilization coincides roughly with the amount of octane potential in the refinery at any one time. Notice, too, that each increase is higher than the preceding one. This is largely because the refiner's total gasoline volume will increase.

It must be remembered that this

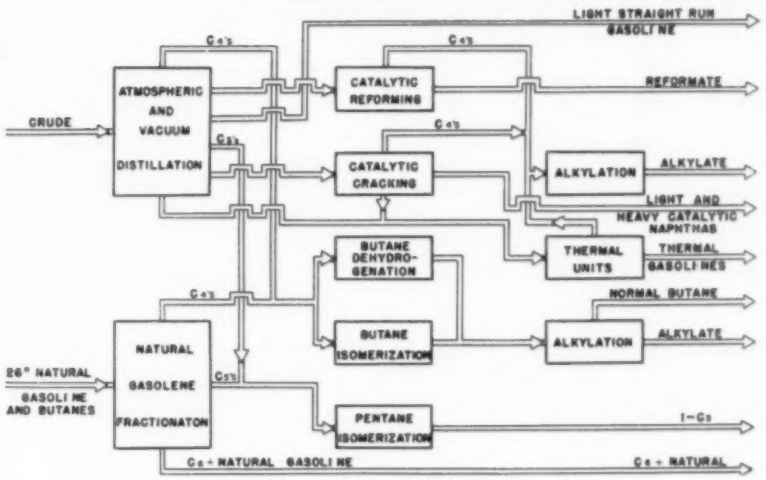

FIG. 7. Simplified flow plan "average" refinery 1977.

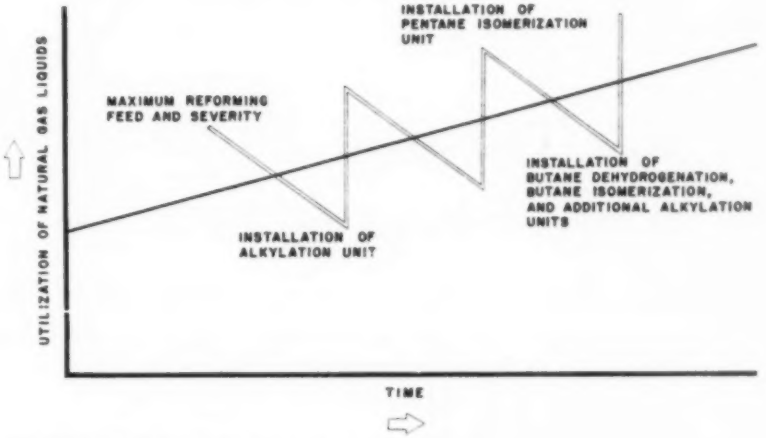
INSTALLATION OF PENTANE ISOMERIZATION UNIT
MAXIMUM REFORMING FEED AND SEVERITY
INSTALLATION OF BUTANE DEHYDROGENATION, BUTANE ISOMERIZATION, AND ADDITIONAL ALKYLATION UNITS
INSTALLATION OF ALKYLATION UNIT
UTILIZATION OF NATURAL GAS LIQUIDS
TIME

FIG. 8. Utilization of natural gas liquids for "average" refinery.

picture is only for one "average" refinery. In the majority of cases it will be impossible to build, operate and adequately amortize the high cost upgrading facilities at the prices refiners are paying for natural gasoline today. Because of this, as the octane of natural gasoline becomes poorer and poorer relative to the total gasoline pool, many refiners will completely discontinue or at least drastically curtail their use of natural as a blending stock. The same thing holds true, incidentally, for the price of natural gasoline, i.e., as the price goes higher and higher refiners will cut back on the amount used. Any prolonged curtailment in natural purchases at any one time or in any one area resulting from octane and/or price considerations will create local oversupply situations. This in turn will enable some refiners to obtain natural gas liquids at reduced price levels which will make installation of upgrading processes economically feasible.

For those refiners who do upgrade, many will elect to have no steps in this curve; some will shift the curve far to the left, or up, or down; others will add process units in another order, etc. As a result the individual "jogs' in this curve flatten out and this curve will be very nearly a straight line.

Future . . . Feed Stock

This leaves one question: Considering this line as a demand curve, long range, what direction will it take? Can overall demand for natural gasoline be expected to increase, or will demand fall off as motor fuel octanes rise? The answer to this question hinges on the fact that natural gasoline has always played an important part of the nation's motor gasoline pool. As a result, the demand for natural has kept pace with the overall demand for motor gasoline. This should continue, but natural gasoline must change from a blending stock to a feed stock. Thus, in a new role as feed to an upgrading unit, the future of natural gasoline will be bright. ★ ★

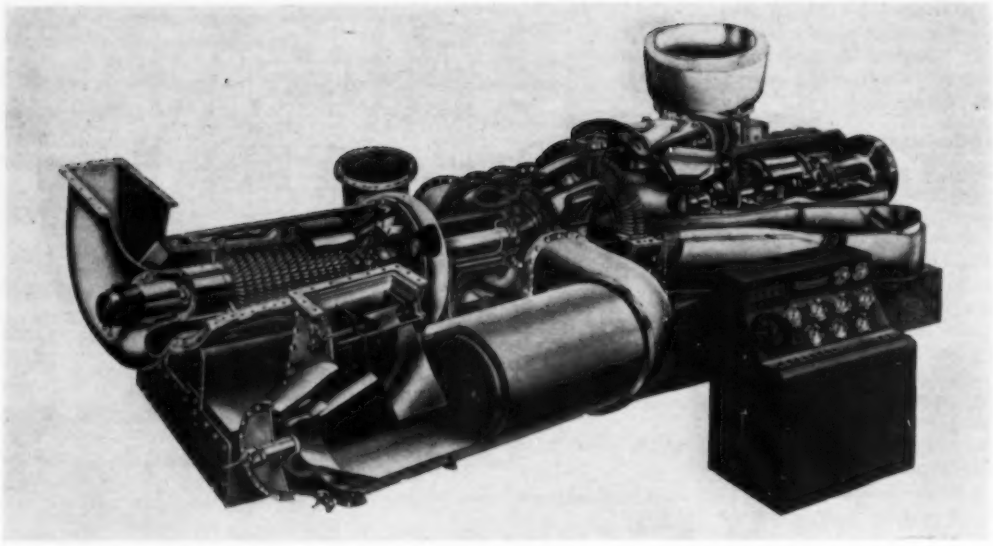

FIG. 1.

Gas Turbine Applications in Gasoline Plants

Space, time and money-saving methods for utilizing various characteristics of the increasingly popular gas turbine

C. R. Apitz
Clark Brothers Company
Olean, New York

GAS TURBINES have been applied profitably in an increasing number of operations in the oil, gas, and petrochemical industries during the last few years, due to reduced installation and operating costs that they offer. Commercial gas turbines have recently become available in the horsepower range that make them adaptable to the needs of normal gasoline plant process design. This article is an evaluation of gas turbine design and waste heat recovery techniques.

The turbine described is an open cycle, combustion gas turbine, rated at 1265 bhp at 80 F ambient temperature and sea level (Fig. 1 & 2).

The gas turbine becomes most advantageous when analyzed as an energy converter, efficiently converting fuel energy to shaft power and economically recoverable heat. The gas turbine has distinct advantages when used only as a prime mover, but profitability is many times greater in areas such as gasoline plants where both facets of its output capabilities can be fully utilized.

Turbines can be used to drive pumps, compressors and generators. One scheme has also been worked out in which both a generator and reciprocating compressor were to be driven by a single turbine output shaft while still retaining adequate control of the two individual machines. The turbine has several advantages over other prime movers, such as lower installation cost, lower maintenance and lube oil cost, less downtime for inspection and adjustment, and less operator attention.

When the advantages outlined above as a prime mover are coupled with the fuel savings achieved by efficient heat recovery equipment the profits that accrue to the use of gas turbines become outstandingly significant. A gasoline plant offers many uses for the turbine exhaust heat, such as production of process steam, process hot oil heating, reboiler stream heating and vaporization loads, and as heat source for dehydrator regeneration.

Application of the gas turbine to its maximum profitability must begin early in the process and design considerations. This is not to say that the gas turbine cannot be super-imposed upon existing plant design to achieve a profitable application to the power-heat requirements of a given plant, but the initial and operating savings that can be realized from the application of this equipment is a direct function of how early in the design they are considered.

Very shortly, the world's first completely gas turbine-powered gasoline plant will be placed in operation in Western Oklahoma. The turbines will drive generators that supply electricity for the entire plant. Turbine exhaust heat will be recovered in a convection heater which, with some supplementary firing, will supply the entire plant's process heat requirements. A general schematic illustration of the arrangement is shown in Fig. 3.

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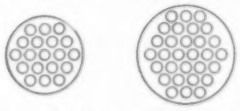
✓ Because Trufin is an extended surface tube—with fins extruded right from the tube wall—it has more than twice the heat transfer surface of plain tube. Less tube is required because Trufin transfers more BTU's per foot of tube.

✓ Fewer tubes mean smaller shells, headers, baffles, etc. This saves material requirements.

✓ Fewer tubes mean fewer holes to drill—less rolling-in operations. Direct result: substantial savings in labor costs.

✓ To transfer a given heat load—when Trufin is used—much less weight of over-all tube metal is required. This is a real saving when expensive alloys are necessary. This is of greatest importance when alloys are in short supply, as a given quantity of metal in Trufin transfers much greater heat loads.



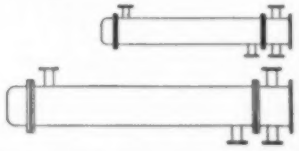
FEWER TUBES
MEANS SMALLER SHELLS

✓ Because of these material savings, lighter units—requiring less structural support—can be designed. This is vital when exchangers are to be mounted on superstructures.

✓ Maintenance costs are low. Costs of replacement tubes are reduced; fewer tubes result in less cleaning time, more "on stream" time. Actual operating data proves that Trufin withstands fouling for longer periods than does prime surface tube. This increases the length of operating time between change-overs.

EQUIVALENT TUBES
WITH THE SAME SURFACE

✓ Smaller, lighter units result in easier handling and lower shipping costs.



TRUFIN
MEANS
SMALLER
UNITS

✓ Where space is at a premium—as in revamped units—Trufin units are smaller.

There they are—eight job-proven ways in which Wolverine Trufin Type S/T condenser tube can save you money. Write for a copy of Wolverine's new Trufin Catalog today!

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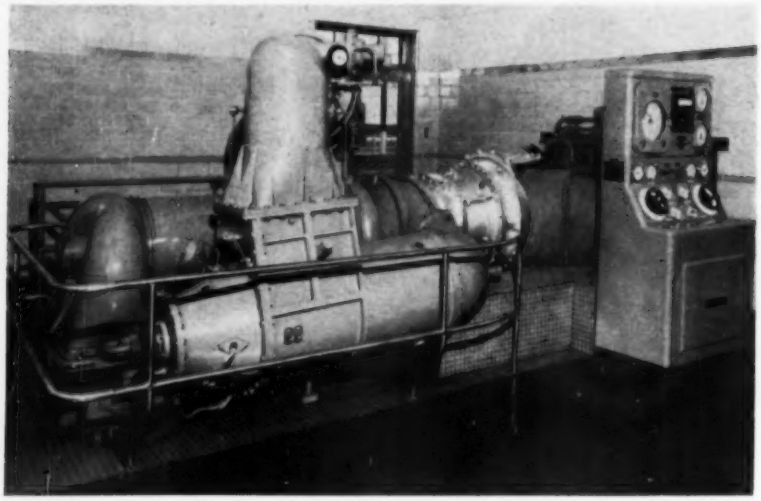

FIG. 2.

Possible New Plant Applications

In general, as was mentioned above, the turbines may be used for driving pumps, centrifugal compressors, and generators. They may be used for pump drives whenever the capacities fall in the range of the turbine. In considering re-compressor loads, it should be remembered that the wide variation in capacity and compression ratio experienced in various gasoline plant operating requirements necessitates a considerable flexibility in achieving the proper balance in the type of compression equipment to be used. There is a tendency to select all one type of compressor or another for gasoline plants — either all reciprocating compressors or all centrifugal compressors, ruling out one or the other type of compressor on the basis of its use throughout the entire compression problem. This need not be the case and in many instances, such as plants where the field pressure is declining or is extremely low, centrifugal compressors can be used quite profitably to take field pressure variations. This allows reciprocating compressors to operate under constant conditions and also eliminates the extremely large reciprocating compressor cylinders often encountered in low pressure plants. The speed control available on gas turbine driven centrifugal compressors can take the variations in plant suction pressure automatically. In these low-pressure plants the use of gas turbine centrifugal compressors can save on installation and operating costs by eliminating large compressor cylinders, valves and headers.

In many plants that operate at essentially pipeline discharge pressures, the volume of gas to be handled in the higher stages is too low for an efficient centrifugal compressor. However, due to the fact that the centrifugal compressor adapts itself so well to conditions experienced in the decline of a producing gas field, a combination of centrifugal and reciprocating compressors can be used in a proportion dictated by the amount of process heat required by the plant, which can be supplied by a given number of gas turbines.

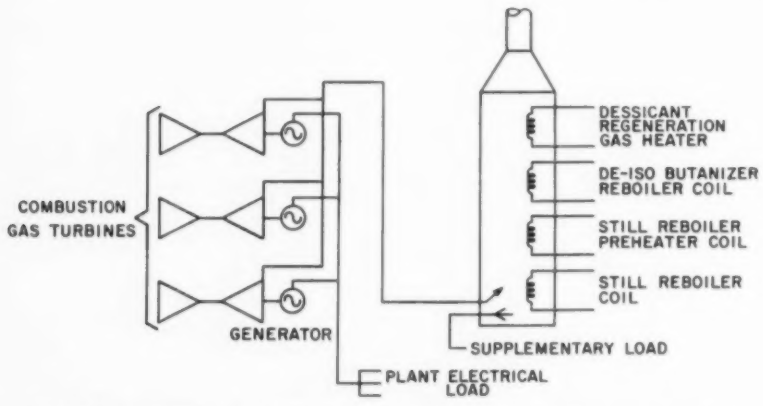

FIG. 3. Schematic diagram of power-heat flow for gas turbine powered gasoline plant.

Power Generation

Use of gas turbines for electric power generation needs no particular analysis except that many times the electrical load of a plant can be raised or lowered to allow the use of a gas turbine for realization of the process heating loads that it can satisfy.

Waste Heat Recovery

One of the basic questions to be answered early in the determination of the plant design is the source of a process heat. Is it to come from the use of steam or direct fired heaters?

There are three basic schemes by which turbine exhaust gas can be utilized. First, as shown in Fig. 4, heat in turbine exhaust gas can be transferred to the process stream by a regular heat exchanger, in which the process stream to be heated can be in series or parallel with a conventional direct-fired heater. After the turbine exhaust gas has gone through the shell side of this heat exchanger, the stream can be split and the amount of the turbine exhaust gas, containing 17 percent oxygen by volume, that can be utilized by the fired-heater is ducted to it as preheated air. The remainder, in excess of the mass that can be handled by the radiant section of the heater, is either ducted to the convection section of the heater or is exhausted to atmosphere. This arrangement can be adapted to either a steam boiler or direct-fired heater.

The second method, as shown in Fig. 5, is to use a conventional heat exchanger that takes the total gas turbine exhaust gas mass flow, and exchanges the heat to the process stream. If their turbine exhaust gases do not contain sufficient heat, supplementary fuel may be added by installing an in-line burner in the ducting ahead of the heat exchanger. This arrangement is limited because of the maximum permissable inlet gas temperature to the heat exchanger tubes, but in many cases it does represent a simple and relatively inexpensive method of accomplishing the desired process heating requirements and still allowing process control.

Until recently boiler and heater designs normally used in gasoline plants were of fairly standard design that included a high proportion of radiant heating surface and a relatively low proportion of convection heating sur-

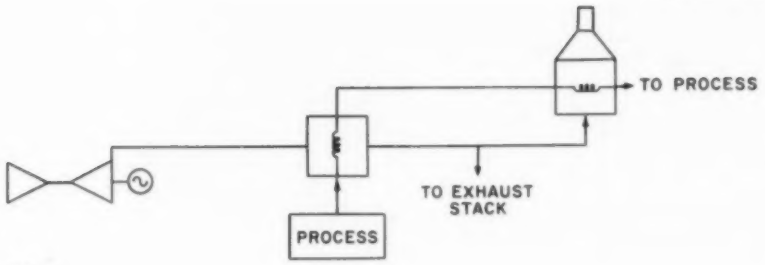

FIG 4.

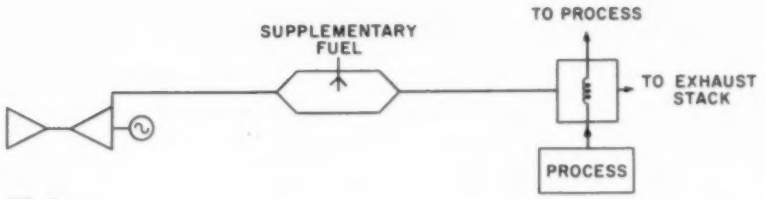

FIG. 5.

face. This high proportion of radiant heating surface limits the mass flow of combustion gases which can be efficiently utilized without experiencing excessive temperatures in the stack or secondary transfer sections of the boiler or heater.

A new type of packaged heater as shown in Fig. 3 has recently been developed that can operate on turbine exhaust gas and can replace either boilers or direct fired heaters in line with the dictates of the plant design. This equipment contains 100 percent convection heat transfer surface. It utilizes fin-tube exchanger surface and operates in an extremely efficient manner with flow densities approximately eight times those allowed in previous conventional designs, while maintaining extremely low stack temperatures in comparison to the conventional heater and boiler designs of comparable size. The unit is completely packaged and its initial price, as well as installation cost, is competitive or lower than the conventional designs.

Supplementary Heat

In many instances the number of turbines that can be utilized in a plant will not put out sufficient exhaust gas to satisfy the process heating requirements by transfer alone. The heater can be equipped with auxiliary burners for temperature control or supplemental heat as is required to take variations in plant design and operating loads' service. It can be designed to house heating coils for more than one service and control the temperature levels for each service. As an example, multiple reboiler levels can be stacked in the unit so that high temperature reboiler coils can be installed in the bottom of the unit and transferred against high temperature incoming exhaust gas. Likewise, lower temperature reboiler coils can be placed in the top of the unit and transferred against relatively low temperature exhaust gas as it is about to go out the stack. This design solves one of the major problems in conventional waste heat recovery equipment, as it operates on extremely low pressure losses and thus does not impose pressure drops that seriously derate the horsepower output of the gas turbine.

Expansion of Existing Plants

Many questions must be answered before expansion can begin. What additional power is going to be required for pumps, compressors or electric power generation? It is possible to lump some of the power requirements to fit available gas turbine ratings and obtain an improvement in the plant heat balance? What additions are required to the present reboiler loads, steam requirements, heating oil loads, or cooling water needs? Also, what are the total heating requirements based upon the expanded capacity of the plant? What boilers and fired heaters are presently installed and how might they be expanded or converted to re-fire turbine exhaust gas?

Feed Water Heating

In the case of a plant operating on steam for both process heating requirements and mechanical drive power requirements, perhaps gas turbines can be applied to the expansion of mechanical drive loads and the turbine exhaust gas can be used for feed water heating to increase the efficiency of the existing boiler and possibly increase its capacity. Existing boilers might be revised to allow them to operate by refiring turbine exhaust. Of course, due to the particular problems in a plant expansion, it may be that gas turbine exhaust gases can be used for both feed water heating and as a source of preheated air for the existing boilers. If additional boiler capacity is required, waste heat boilers designed to operate on turbine exhaust gas could be installed to operate in parallel with existing boilers. Exhaust gas can be used for both steam production in a waste heat boiler and a supply of preheated air for the existing boilers.

"Dry" Plant

Also, turbine exhaust heat can be applied to a "dry" plant. Any plant expansion would, undoubtedly, require an increase in the process heating loads. The turbine exhaust heat could be used by straight heat exchange to preheat process oil prior to entering existing heaters. In many instances the exhaust gas coming out of the oil preheater could supply preheated air to an existing fired heater that has been revised to refire turbine exhaust. As an alternate to this, a convection type heater could be installed to operate on turbine exhaust gas, in parallel with the existing process heaters on the process side. Exhaust gas coming from this convection heater could, if economically feasible, also be fed into the existing fired heater as a source of preheated oxygen. The type of heat recovery outlined above for oil heating and process steam production can also be considered in conjunction with process re-boiler heating and vaporizing loads.

Close Coordination

The complete application of the gas turbine requires much closer collaboration between process and mechanical equipment than has been previously necessary for other types of drivers. This is due principally to the necessity for achieving the proper power-process heat balance for maximum profitability of the application. If close collaboration is not achieved between vendor, contractor and ultimate user, many applications will be overlooked due to the fact that one of the three parties involved may not fully appreciate the interplay of economic factors and thus misinterpret or fail to interpret the economic flexibility possible in gas turbine application to its maximum profitability. Gasoline plant design is based on a given set of economic factors which constitutes a common starting point for all of the various contractors and their process designers. This is probably the last point at which there is agreement between the various process designers. Some will use various amounts of refrigeration, some will use absorption and some will use a

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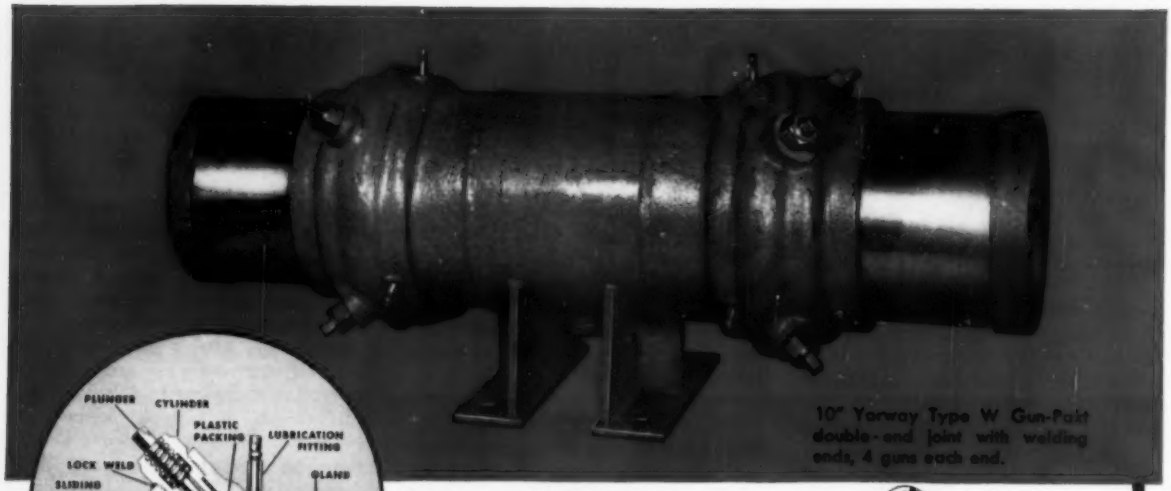

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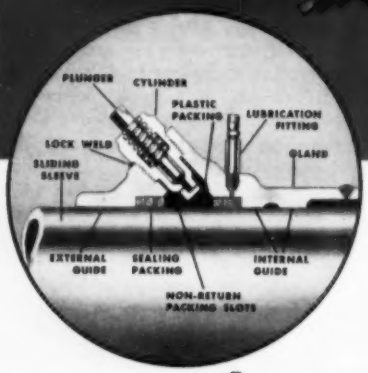

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Flexibility

The gas turbine is extremely adaptable to the various processing gimmicks that are worked out for a given set of plant conditions. However, this flexibility is achieved only by the proper selection and adaptation of its mechanical drive aspects and the more efficient application of the equipment which recovers the turbine exhaust heat. Often, turbine applications have been overlooked since the turbines required to satisfy the mechanical drive loads of the plant were capable of providing more heat than was required in the process. On this basis the process designer often rules out the use of gas turbines on the basis that the process heat requirement to be recovered is not sufficient to obtain a suitable overall plant thermal efficiency that would be competitive with other types of power-heat cycles. Undoubtedly, many of these jobs would represent profitable application of gas turbines if the designer were to make the basic assumption that the exhaust heat is available and then decide how this heat can be used to increase the profitability of the overall plant operation through increased recovery, reduced circulation capacities, or any one of many other factors that affect these overall economics.

Savings

To obtain a complete picture of the possible savings to be achieved through the use of gas turbines, several facts concerning plant site utilities economics have to be considered, such as the local rates for purchased power and the price and quality of the fuel gas. Gas turbines have the ability to use fuel gases of lower quality than many other types of prime movers, and can operate satisfactorily on gases having a high hydrogen sulfide content or a high CO_2 content. They are not sensitive to relatively wide variations in heat content and can operate on gases having a relatively high percentage of heavy ends which are bothersome to gas engines.

Lack of availability of cooling water at the plant site may prove favorable to the use of gas turbines, which require no cooling water. This elimination of cooling water requirements will favor their use in other areas where cooling water is available but of such a poor quality that the cost of water treatment to make the water suitable for use in engines or steam boilers is prohibitive.

Installation Costs

The statement was previously made that gas turbine driven units of various types can be installed at costs lower than those experienced with other types of prime movers. Sufficient data has now been gathered from the installation of many gas turbines to give a pretty clear indication of the actual installation cost that can be expected. Gas turbine driven generator plants can normally be constructed on a complete turn-key plant basis for $175 to $190 per kw. The installation cost of gas turbine driven centrifugal compressor units will vary widely as the cost of the compressor is a function of several variables, including compression ratio, flowing volumes, and discharge pressures and their effect upon compressor construction and auxiliaries. The total installed cost of these units will vary from as low as $130 per hp to as high as $180 per hp. Installation costs on gas turbine driven centrifugal pump units can be pretty well established at between $130 and $150 per

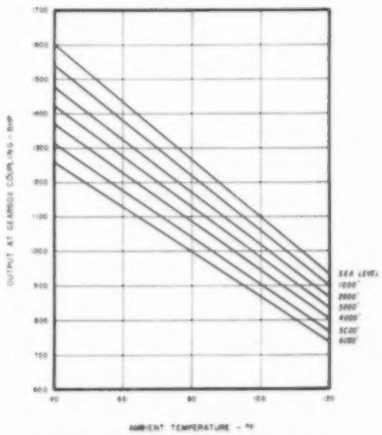

FIG. 6. BHP vs ambient temperature for various altitudes.

hp. The above costs, of course, are a general rule-of-thumb and will vary with the economics factors prevalent in a particular area. The above costs should be sufficient to include equipment, building, foundation, ducting, labor, control piping and wiring, auxiliaries and their installation, and all other costs encountered within the confines of the building. The costs do not include compressor or pump process piping, electrical distribution systems beyond the switch gear panel, turbine exhaust gas ducting from the building to the heat recovery equipment site or the heat recovery equipment itself. These costs have not been included because they are subject to such wide variations from plant to plant that their inclusion would tend to nullify the value of the estimating price as a general rule-of-thumb.

The above installation costs should be lower than practically any other installation that will provide the same flexible combination of mechanical power and process heat. This savings results from lower building costs achieved through a savings in floor space, lower eave height through the elimination of high crane lifts and a lighter building frame due to the elimination of overhead crane requirements and lower weights encountered in normal maintenance. The heaviest piece to be handled during normal maintenance of the unit under discussion in this paper is 500 lb. Further savings in installation costs are achieved due to the reduction in foundation costs. This turbine can be installed on a simple 18 in. slab foundation with a minimum of reinforcing rod due to the low weight of 12,000 lb for the turbine and the low vibration experienced during turbine operation. Additional savings are possible due to the fact that the turbine lends itself very well to complete packaging of piping, controls and wiring at the point of manufacture. This reduces field assembly and erection time to a minimum. Reduced cooling tower costs due to the elimination of cooling water requirements and an extremely low initial spare parts investment of $1200 to $1500 per turbine are additional cost saving features.

Maintenance

Also, savings can accrue throughout the operating life of the turbine. Automatic controls can be readily installed on a gas turbine, freeing the plant operator for other jobs throughout the plant or permitting him to oversee operation of more equipment. The gas turbine under discussion is designed for continuous operation over periods of 10,000 to 15,000 hours between inspections. These inspections can be conducted at an extremely low cost as they can be completed in from 8 to 16 hours, depending upon the skill of the maintenance crew performing the inspection. Our records on the operation of over 60 of these turbines show an average cost for these overhauls of from $50 to $100 for materials and $200 to $300 for labor. This factor alone can represent a savings of several thousand dollars per year when comparing the gas turbines to other prime mover units.

Another area in which the gas turbine represents a decided savings is in the field of lube oil consumption. These turbines have been operating on an average lube oil consumption of approximately 100,000 hp hr per gal.

Fuel Savings

Due to the fact that the turbine can supply both shaft power and economically recoverable process heat, its use in gasoline plants also reflects a savings

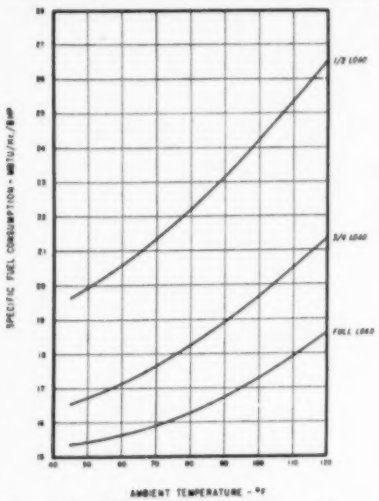

FIG. 7. Specific fuel consumption vs ambient temperature at sea level.

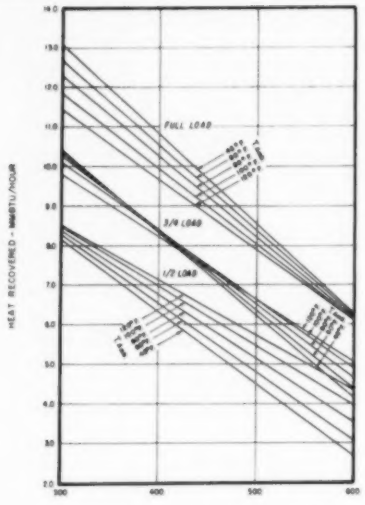

FIG. 8. Heat content of exhaust gas as a function of heat exchanger exit temperature.

in fuel cost. This reduction in fuel cost can be achieved in two different ways. First, here are some actual figures resulting from recovery of the turbine exhaust heat by straight heat transfer. The turbine at its sea level rating of 1265 bhp (see Fig. 6) at 80 F ambient temperature will have a total fuel consumption of approximately 20.5 MM Btu per hr. (See Fig. 7) From the turbine we will recover 1265 bhp which is equivalent to 3.22 MM Btu per hr. We can then recover 10.27 MM Btu per hr (see Fig. 8) in a heat exchanger designed to heat a process fluid by cooling the turbine exhaust gas from its normal exhaust temperature of 890 F to a temperature of 400 F at the heat exchanger outlet. This type of arrangement results in a total overall thermal utilization of the fuel in-put of 65.8 percent.

Thermal Utility

The other manner of turbine exhaust heat utilization which reflects a savings in fuel cost is the arrangement in which the turbine exhaust gases are refired in a boiler or heater. In this instance the sensible heat in the exhaust gases referred to ambient air temperature is approximately 16.75 MM Btu per hr (see Fig. 9) and the total overall thermal utilization of this type of arrangement is theoretically 97.5 percent. The thermal utilization experienced in actual operation will not be quite this high but will be in excess of 90 percent. The turbine exhaust gases may be used in either one of the above heat recovery arrangements or may be used in a combination arrangement involving both types of heat recovery. To obtain a full picture of these possible savings, it is necessary to know both the power and process fuel consumption rates of the other power heat

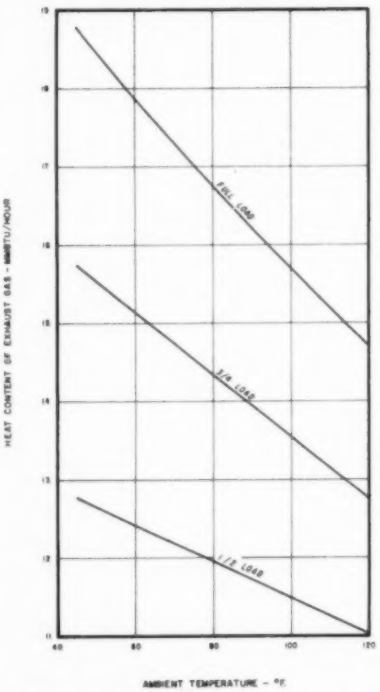

FIG. 9. Heat content of exhaust gases referred to ambient temperature at sea level.

cycles with which the turbine is being compared. Also it is important that the design and process engineers consider the power-heat balance of a plant when using gas turbines as thoroughly and independently as they would consider the steam balances involved in a plant using steam for prime mover work as well as process heat.

Louisiana Plant Study

Now, consider some examples of how the gas turbine can be used to an advantage in a few actual cases. The first is a gasoline plant in Southern Louisiana. This plant has an extremely poor steam balance and a great deal more steam is required for the prime mover loads than can be used in the process. The plant has been in operation for a good many years. It will soon be necessary to replace some worn-out boilers. This particular plant has a steam turbine driven lean oil pump which requires approximately 1100 hp. Installation of a gas turbine for the lean oil pump drive can eliminate the requirement for the steam produced by the boilers that are to be replaced as this is about the amount now being required by the steam turbine driven lean oil pump. The use of the gas turbine will reestablish the power-process steam balance, eliminate a sizable steam condenser load, reduce the cooling tower load by approximately 50 percent and provide enough exhaust heat to substantially reduce the fired heater load. This can be accomplished by the purchase of a single gas turbine.

West Texas Plant Study

Several expansion problems faced a gasoline plant in West Texas. The expansion was such that an increase in electric power, propane refrigeration and process heat requirements would result. Analysis of these various incremental requirements indicates that one Clark Model TA turbine driving a generator could supply sufficient electric power to meet the increased electrical loads and supply electric power to an electric motor driven propane refrigeration compressor. The exhaust heat from this turbine would be sufficient to provide the incremental process heat requirement with only a slight amount of refiring. We find that the turbine generator unit and the waste heat recovery equipment can be installed at a savings of approximately 20 percent over the cost of installing

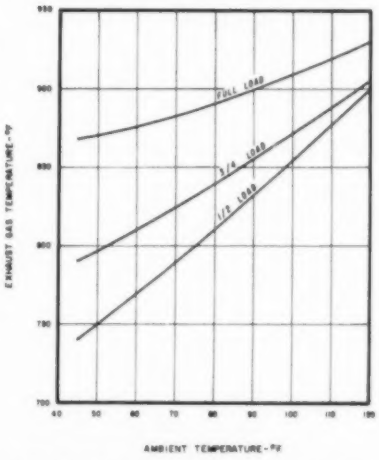

FIG. 10. Exhaust gas temperature vs ambient temperature at sea level.

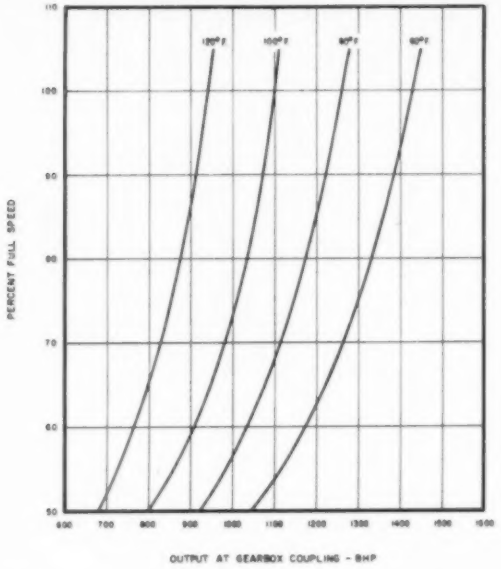

FIG. 11. Horsepower output vs percent of rated speed at various ambient at sea level.

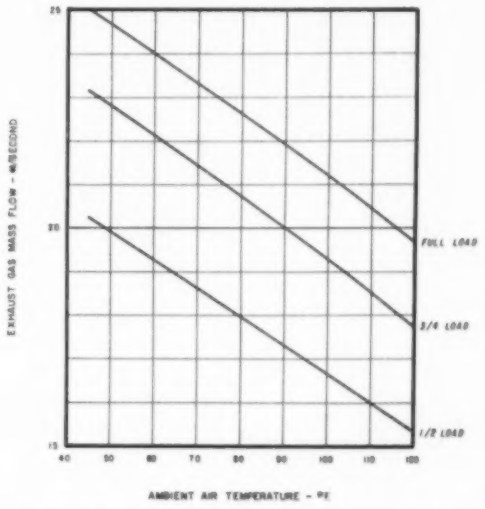

FIG. 12. Exhaust gas mass flow vs ambient temperature at sea level.

one additional gas engine driven generator unit, an additional gas engine driven propane refrigeration compressor and an additional fired heater. We also find a savings of approximately 20 percent in the fuel cost of the turbine as compared to the fuel consumption of the additional engines and fired heater. This operating savings is further increased by the savings in maintenance and lube oil realized from the use of turbines as compared to engines.

New Plant Study Prospect

Now let us consider the application of gas turbines to a new plant. This particular plant requires two gas turbines for propane refrigeration which should be installed for about $400,000. It also includes a gas turbine generator unit which should be installed for approximately $190,000, making a total installation cost for the three units of $590,000. This represents a saving when compared with a gas engine driven reciprocating compressor and generator installation. Further analysis indicates that the heat recovery equipment to operate all gas turbines will be competitive or slightly cheaper than direct fired heaters for the process heat requirements.

The process heat requirements in this particular plant are approximately 40 MM Btu's. 33.9 MM Btu of this can be recovered from the turbine exhaust gas leaving an additional fuel required of approximately 6.1 MM Btu per hr.

The total fuel consumption of the turbines and the auxiliary fuel for the heater will amount to 67.9 MM Btu per hr. The fuel consumption for the three engines will be 29.8 MM Btu and the 40 MM Btu fired heater at an efficiency of 80 percent will have a fuel consumption of 50 MM Btu per hr, bringing the total fuel consumption of the combined power-heat facilities to 79.8 MM Btu per hr. Thus we have a turbine arrangement.

The maintenance for the three gas turbines and their associated driven equipment will amount to about $3000. The lube oil consumption for the three gas turbines is 326 gal per year. This brief analysis shows that some very definite savings are to be gained by the use of gas turbines in gasoline plants, providing there is a proper balance between power requirements and process heat requirements.

The economic balances outlined above can be very definitely altered by revisions in process conditions but, of course, everyone is striving for the maximum profit in gasoline plant design and operation. Sometimes this can only be arrived at by revision of some of the old methods of plant design.

Gas turbine design and application have made rapid progress in the past few years. They are now available in sizes that meet the mechanical drive requirements of many gasoline plants. Over 60 units of the turbine model discussed in this paper have been installed and have accumulated over 200,000 operating hours. The installation and operation of these units has provided a great deal of data concerning the costs involved, indicating that savings can be achieved by the use of gas turbines.

Gas turbines are now being considered for pump, compressor and generator drive. The exhaust heat is being analyzed on the basis of steam production, oil heating, and as a direct reboiler heat source. Additional uses for turbine exhaust as heat for dehydration unit desiccant regeneration and absorption refrigeration are also being developed. Fuel savings will result when the optimum balance is achieved for mechanical drive and process heat requirements. This is obtained by close collaboration between the manufacturer and the process designer.

Automation

Much has been said in recent years about automation and remote operation of all sorts of plants by computers. The turbine described above has been developed to permit remote starting, stopping, monitoring of operational check points and speed and load control to permit process variation.

Future

In the next few years further advances in the design and application of gas turbines and waste heat recovery equipment are expected. The speed with which these advances are accomplished will be a function of the creative thinking and collaboration of the engineers of the manufacturer, contractor and user. ★ ★ ★

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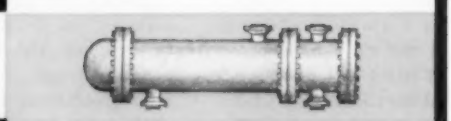

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Velocities Are Critical in Two Phase Gathering Systems

Here are some design factors to consider when planning a system to supply your gasoline plant

Don Green and Dr. R. L. Huntington
University of Oklahoma, Norman, Oklahoma

TO MEET THE INCREASING DEMAND for petroleum from year to year, the industry has had to drill to greater depths to find adequate reserves of oil and gas. In these deeper formations, higher pressures and temperatures prevail and result in retrograde vaporization, causing a single phase fluid state to predominate. In such reservoirs, all hydrocarbons from methane to the high molecular weight compounds with boiling points as high as 500 to 600 F are present as one single phase fluid, which is neither a gas nor a liquid. Gas-condensate fields of this type are to be found everywhere; however, in the United States, there is a greater concentration of such reservoirs in the Gulf Coast region.

From the very nature of this gas-condensate single phase reservoir fluid, unitization is found to be the most feasible and economical method of producing these fields. Without unitization, various operating difficulties would arise, such as the transport of fluids through the reservoir from one lease to another due to unequal withdrawal and re-injection rates by different companies within the same field. Many other unavoidable inequities would result from competitive operation of properties by their respective companies, hence the marked trend toward the cooperative arrangement, making for maximum earnings to the companies and royalty owners as well as conservation of our natural resources.

Central Plant and Gathering System

With unitization, collecting and gaging the liquids on each lease is no longer necessary so far as the royalty owner is concerned. It has become standard practice in most gas-condensate fields to transport the liquids and gaseous hydrocarbons from the wells to the central recovery or natural gasoline extraction plant through one common network of gathering lines. Although the gas carrying capacity of any pipeline is markedly reduced by concurrent flow of liquid condensate, economics can be effected for several reasons.

1. Variation in flow rates from the wells makes it difficult to design for the most economic pipe size,
2. Two smaller lines for separate flow of gas and liquid cost more as a rule than one large line,
3. Cost of laying and maintaining two lines is usually greater than it is for one.

Early Gulf Coast Experience

The Tepetate field in Southern Louisiana was one of the first in which the industry gained valuable experience in the concurrent flow of gas and condensate through a common gathering system. In this field, Bennett [2] and his coworkers of Continental worked out an empirical correlation based on data they obtained from the pipelines which supplied the central recovery plant. This simple correlation, with an example, is given for the benefit of pipeline designers who may wish to compare it with the experience of more recent investigators.[1]

TO CALCULATE CAPACITY OF COMBINATION OIL-GAS PIPELINES

(Continental Oil Company Method based on Louisiana condensate field data) (field lines were in level country).

1. Determine maximum gas capacity for the given pressure drop, line size, specify gravity, and flowing temperature,
2. Determine maximum oil capacity for the same pressure drop and line size, and for the specific gravity and SSU viscosity of the oil. Convert gallons per minute to cubic feet per day,
3. Gas-oil ratio of line capacity $= \frac{\text{No. 1}}{\text{No. 2}}$
4. Determine gas equivalent of oil actually transported in line. (Barrels per day $\times$ 5.615 $\times$ No. 3 = Mcf/day);
5. Gas that will actually flow with the actual volume of oil equals

$$\frac{\text{No. 1} - \text{No. 4}}{1.2} = \text{Mcf/day.}$$

Notes:

1. No. 1 above can be determined from the gas chart.
2. No. 2 above is a "cut and try" proposition. Use the three charts for liquid flow through pipes. Select a gallons-per-minute figure and run through the three charts to determine pressure drop per thousand feet of line. If this pressure drop is not equal to the pressure drop used for maximum gas flow, then select another gallons-per-minute figure and repeat. This must be continued until a gallons-per-minute figure is found that will give the proper pressure drop.
3. The factor of 1.2 in No. 5 was developed experimentally from actual data.

Example:

Determine maximum gas capacity for an 8-in. line, 95,000 ft long, 1000-lb inlet, 900-lb outlet, when carrying 1400 bbl/day, 0.7 sp. gr. gas at 80 F and 43 SSU viscosity oil of 0.81 sp. gr.

1. From chart —
   Maximum gas flow = 23,000 Mcf/day
2. From three oil charts —
   Maximum oil flow = 390 gal/min
   = 75,080 cu ft/day.
3. Gas-oil ratio of line =
   23,000,000 ÷ 75,080 = 306.34
4. Gas equivalent of oil actually flowing =
   1,400 bbl $\times$ 5.615 $\times$ 306.34 = 2,400 Mcf/day
5. Gas capacity =
   $\frac{23{,}000 - 2{,}400}{1.2}$ = 17,166 Mcf/day.

The line will carry a maximum of 17,166 Mcf/day when carrying 1400 bbl of oil.

A number of other Gulf Coast unitized fields have provided additional information on the feasibility and economy of concurrent multi-phase flow of gases and liquids. To enumerate a few such fields, there are Cotton Valley near Shreveport, Louisiana, Erath in Southern Louisiana, and Katy, 40 miles west of Houston. All of these fields happen to be located on level surface topography, therefore the Continental correlation based on Tepetate has

proved to be satisfactory for these areas. In the early fifties, the Arkansas-Louisiana Gas Company started the transportation of gas and condensate through a 16 in. pipeline in the northeast part of Texas, near Marshall, and found that the presence of hills between two stations, with the same elevation, caused an excessive pressure drop of 350 psi as compared to 30 psi predicted by the horizontal correlation. Flanigan[5] has recently reported this experience as a part of a comprehensive study he and his associates have made on multi-phase flow.

Other companies, namely Shell at Elk City, Oklahoma, West Coast Transmission in northeast British Columbia, and British-American in Pincher Creek, Alberta, have encountered operating problems as a result of transporting gases and liquids in hilly country. Berry[3] et al have reported some of their field experience in British Columbia in recent publications.

Field-Testing Research

About five years ago the Continental and Magnolia Petroleum companies carried out some gas-condensate concurrent flow tests in several miles of 10 in. followed by the same length of 8 in. pipe in a level stretch along the Gulf Coast. They found that the pressure drop was greater through the 10 in. section for some of the low gas-condensate ratio runs than it was through the 8 in. section. This unexpected phenomenon was caused by slugging in the 10 in. pipe, while the higher mass velocity in the 8 in. pipe produced a better liquid sweep efficiency and consequently a lower pressure drop with no liquid slugging, demonstrating that a two-phase pipeline can be oversized just as readily as it can be undersized.

Experimental Research

A number of universities[6, 7, 8, 9, 10, 11] have undertaken experimental studies during the past decade in an attempt to solve some of the problems connected with multi-phase concurrent flow of fluids which could not be clarified through field data alone. Although the pipelines in the schools had to be smaller than the field lines, the investigators had better control of such variables as mass flow rates, gas to liquid ratios, temperature, steady-state conditions, etc. Also they were able to obtain visual data through the use of pyrex sections and clear plastic tubing. From such information, a better idea of flow patterns could be had. Slippage could also be determined experimentally by shutting in the pipeline section under observation and measuring the ratio of liquid to gas "in situ" as well as the flowing ratio. In all cases it was found that the gas flows at a higher linear velocity than the liquid, hence the tendency of the liquid to accumulate in the pipeline.

Don Green holds a BS degree in petroleum engineering from Tulsa University. He had one year's experience in the Gulf and Carter Production laboratories before entering the University of Oklahoma in February 1958, where he is working toward an MS degree in chemical engineering.

R. L. Huntington holds a PhD degree in chemical engineering from the University of Michigan, and has had 10 years of experience in the operation and construction of natural gasoline plants (1920-1930). Since 1933, he has been a professor of chemical engineering at the University of Oklahoma. During this period, he has served as consultant to a number of petroleum and chemical companies. Huntington is author of a number of papers related to petroleum technology, and of *"Natural Gas and Natural Gasoline,"* McGraw-Hill, 1950.

Up and Downhill Flow

Brigham,[4] Holstein et al were among the first investigators to make an experimental visual study of multi-phase flow through inclined piping. Their work has been extended recently by Green et al at the University of Oklahoma by flowing gases and liquids at steeper inclines. In the following paragraphs of this paper, some of the experimental results by Green and his co-workers are reported.

The experimental equipment employed by Green was essentially the same as the flow assembly used by Brigham and Holstein. The 2 in. ID plastic pipe loop was 30 ft in length and 4.5 ft in width with quick closing valves near the inlet and outlet which were used for obtaining "in situ" ratios of gas to liquid.

The use of clear Tenite tubing made it possible for Green and his assistants to make visual observations from which flow pattern charts have been drawn up — in Fig. 1, 2, and 3 for various air and gas-oil flow rates and at horizontal, 2 and 33 degree inclines respectively.

Other investigators have reported flow patterns in which there is fair agreement. However, it is difficult to allocate these patterns since the transition from one type of flow to another takes place quite gradually. Furthermore, word descriptions of a flow pattern for a certain visual experiment are apt to vary between several observers who may be watching the same experiment.

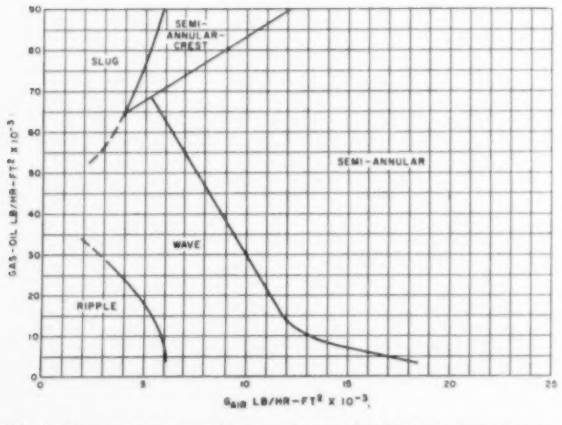


FIG. 1. Flow pattern chart for air and gas-oil in horizontal concurrent flow.

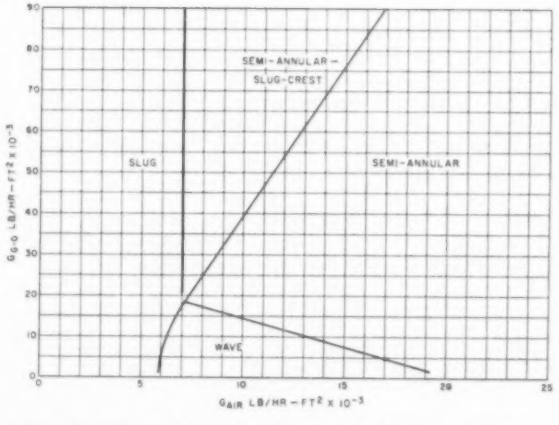
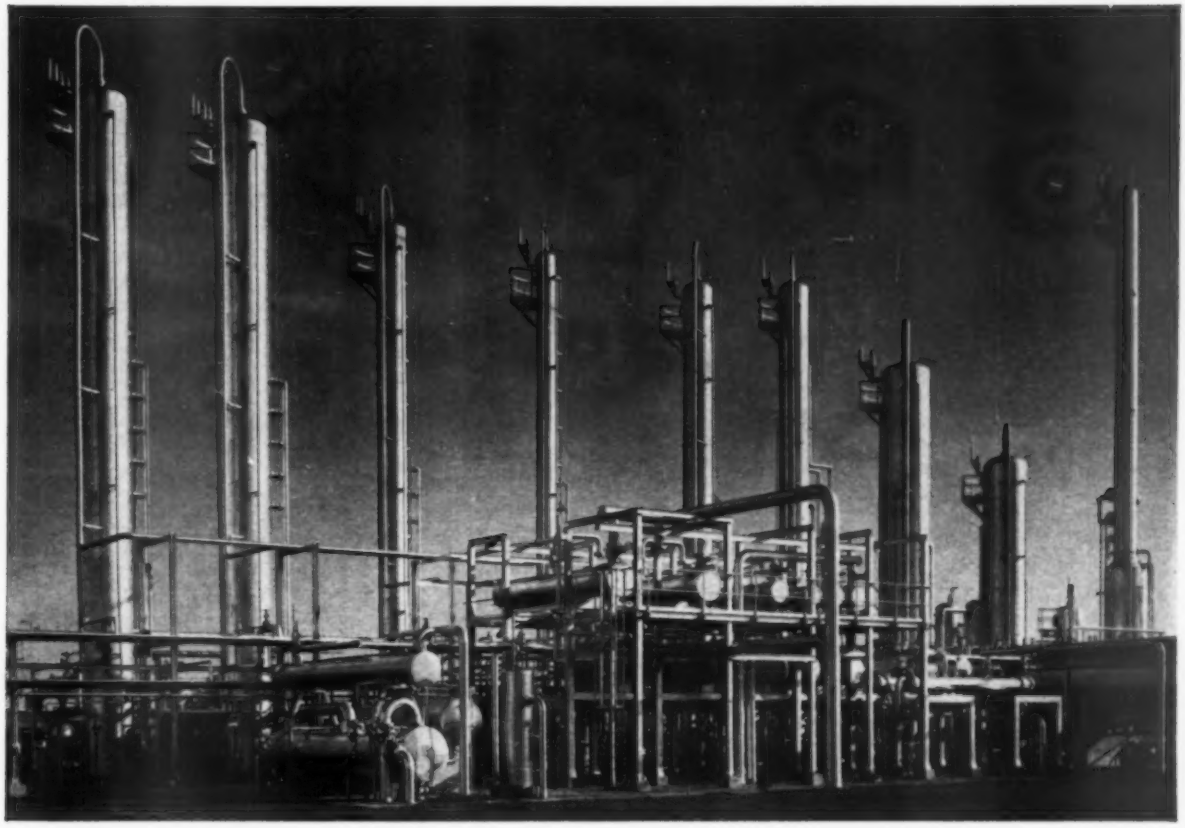


FIG. 2. Flow pattern chart for air and gas-oil in concurrent flow at 2 degree incline.



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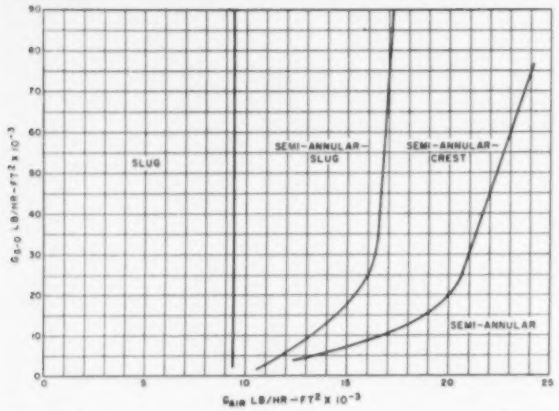

FIG. 3. Flow pattern chart of air and gas-oil in concurrent flow at 33 degree incline.

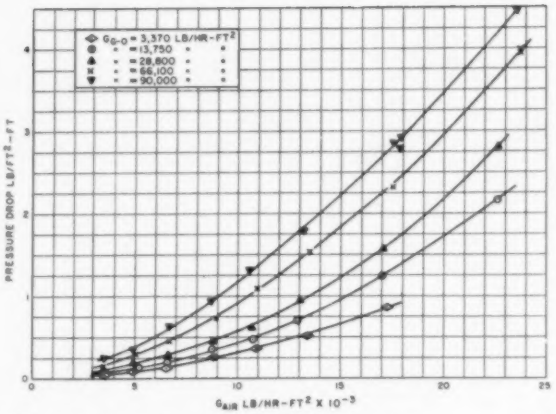

FIG. 4. Horizontal concurrent flow of air and gas-oil.

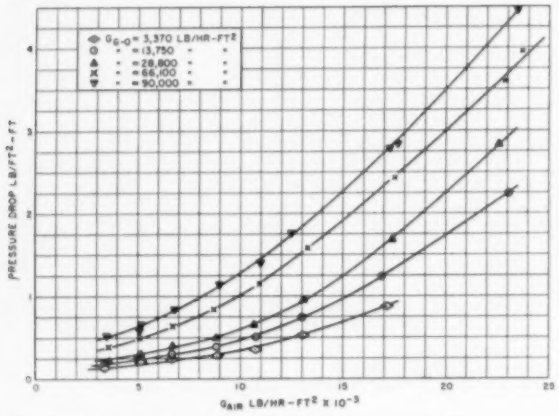

FIG. 5. Concurrent flow of air and gas-oil at 2 degree incline.

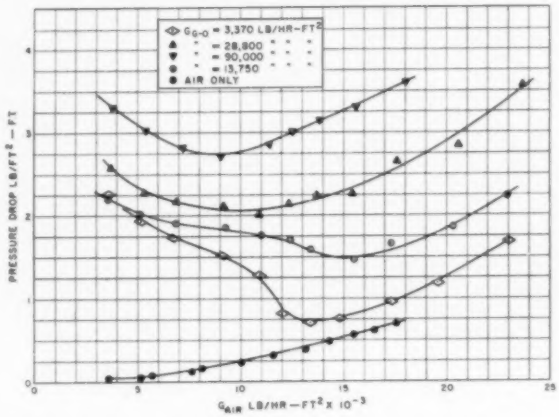

FIG. 6. Concurrent flow of air and gas-oil at 33 degree incline.

Motion Picture Studies

A number of 16 mm colored motion pictures have been taken at the School of Chemical Engineering — University of Oklahoma of various concurrent multi-phase fluid flow experiments. These movies include air and water, gas and oil, and air, water, and oil (3 phase) flowing horizontally, up and down inclines and vertically upward, both at normal motion and at 800 frames per second (1/33 normal motion) when shown on a projector. These silent movies contain titles giving the flow rates for gas and liquid for the numerous conditions under which the experiments were made.

Experimental Pressure Drop Data

Data shown in Fig. 4, 5, and 6 are for horizontal, 2 and 33 degree inclines respectively. The agreement with previous investigators is very good for Fig. 4 and 5 with the pressure drop increasing geometrically with air flow rate for lines of constant liquid flow rate. Fig. 6 differs, however, since the steep incline creates a high static liquid head which must first be aerated. These curves take the general shape of those reported by Galegar and Stovall[6], and Govier[7], et al which represent vertical flow studies. To the left of the minimum pressure drop for each liquid flow rate, slugging predominates, and to the right of the minimum, semi-annular — spray flow takes over. These tests bring out the importance of maintaining high mass velocities for gas flow, especially in hilly country in order to prevent slugging conditions within the pipelines.

Conclusions

Concurrent multi-phase flow of gas and condensate through common gathering lines has proved to be an economical method of transporting fluids from producing wells to central recovery plants in a number of unitized fields located in level country. In hilly areas the advantages of concurrent flow are offset by increased pressure drops caused by slugging on uphill slopes. In such cases, each field presents a problem of its own.

Much additional knowledge is needed before a clear-cut understanding of all pipeline design factors can be realized.

Acknowledgment

The authors wish to express their appreciation to Westcoast Transmission Company and Pacific Petroleum Ltd. for the financial support which these companies provided for a graduate fellowship and the purchase of certain special equipment needed for the experimental program. Undergraduate students (Dean Niles, Larry Glasgow, Dick Boyer, Dan Tucker, Eugene Cheatham and Ray Lohman) provided much assistance in the construction and operation of the flow equipment during the experimental period.

We should also like to express our appreciation to the Hughes Tool Company of Houston for the high-speed photographic work which was provided gratis through their A. R. Baldwin.

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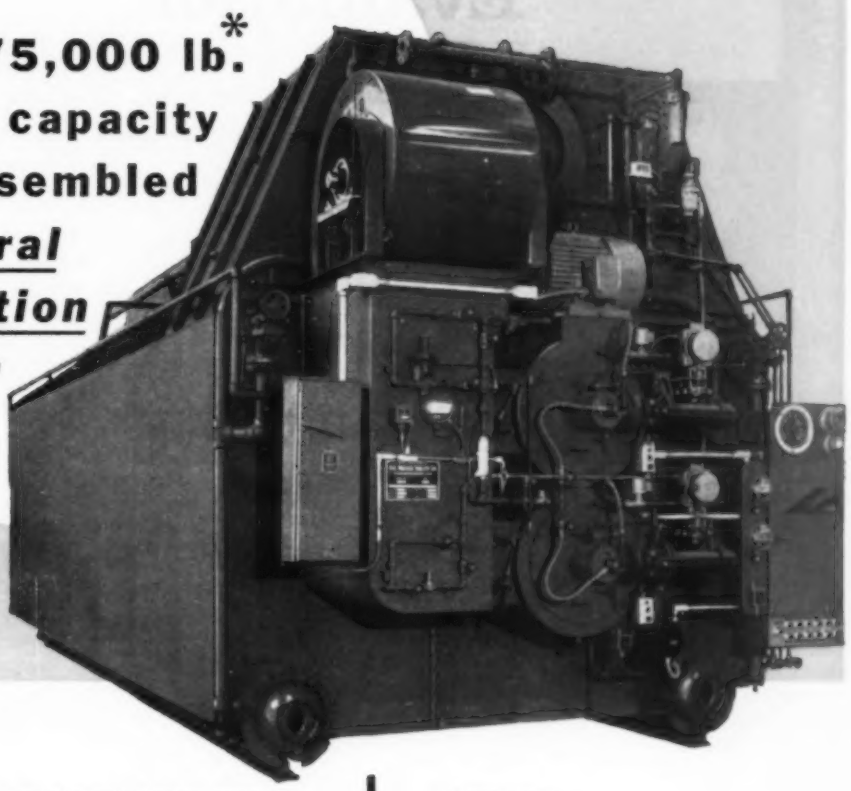

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Deethanizer Performance Evaluation

Arnold J. Gully
Mississippi State University
State College, Mississippi

. . . Points out the need for more accurate hydrocarbon enthalpy data . . . suggests industry-supported research program

THE USE of rigorous computational methods, which is possible with high speed computers, does not necessarily produce reliable answers to process engineering questions. Confidence in predictions arrived at through engineering calculations can only result from the combination of sound methods and accurate basic data. Machine computations are becoming more and more prevalent in fractionator calculations. A re-evaluation of the available data on vapor-liquid equilibria, enthalpy and tray efficiency in the light of recent advances in computational methods seems desirable.

The evaluation of basic data used in fractionation calculations was the primary object of this study. In particular, efforts were made toward determining the reliability of existing correlations on equilibria and enthalpy at pressures approaching the convergence pressure. Results of computations using various correlations on properties were compared with carefully determined performance data on a deethanizer operating at 453 psig. The magnitude of differences between calculated and actual conditions reflects the reliability of the basic data used. Whereas this approach cannot be expected to yield precise results, it does point to areas which are in need of attention.

While most equilibrium data appear quite good, errors which are less than 10 percent seriously affect separation predictions. Almost equally good agreement with experiment was obtained with each of two K methods, one at a tray efficiency of 77 percent and the other at 118 percent. Repetitive non-random differences are cumulative, making consistency between equilibrium evaluation method and tray efficiency imperative.

Overall column separation prediction results are not greatly affected by enthalpy correlation differences. However, liquid and vapor rates, which determine column capacity, and heat loads are functions of variations of component enthalpies with temperature and composition. Large savings through close design appear possible with better enthalpy data. Experimental data in the light hydrocarbon enthalpy field are scarce and progress in this area appears necessary.

THEORY AND LITERATURE SURVEY

Theoretically, both enthalpies and K values for hydrocarbon systems can be evaluated from pressure-volume-temperature-composition relationships along with heat capacity data on the pure components at one pressure. The latter is necessary only for enthalpy calculations. Since accurate evaluation of thermodynamic properties requires that corrections be made for deviations from ideality as to solutions as well as gases, rigorous methods of prediction are inherently extremely complex and require extensive experimental data.

Vapor-Liquid Equilibria

It is generally agreed by authorities in the field that the empirical equation of state for hydrocarbons developed by Benedict, Webb and Rubin [1,2,3] is the most significant advance in recent years in hydrocarbon thermodynamics. However, the derivation of properties from this equation through thermodynamic treatment is far too long and complicated for engineering use. Benedict, Webb, Rubin and Friend [4,5] introduced a molal average boiling point composition parameter in equilibrium constant evaluation and published a series of graphs of K values known as the "Kellogg Charts." These were later consolidated by DePriester.[6]

Another composition parameter which has been used extensively in correlating vapor-liquid equilibrium data is the convergence pressure. Extensive charts based on tabulations by the late G. G. Brown at the University of Michigan have been published by the NGAA in 1955 in its "Equilibrium Ratio Data Book." These charts, which were based on extensive experimental data, are in industry-wide use.

The prediction of equilibrium ratios from NGAA charts requires a determination of the convergence pressure of the mixture based on composition. The NGAA K charts are based on Hadden's [9] method of predicting convergence pressures of multicomponent mixtures. This is essentially the convergence pressure of a binary of the lightest component and a hypothetical heavy component which is equivalent to the average of the heavy fractions of the mixture. Lenoir and White [11] in a recent publication have, while using the equivalent binary concept of Hadden, modified the method of determining the light and heavy hypothetical components. It seems that this method should be more accurate where a trace light component is present. Since results of the two methods do not always agree, there is some doubt as to which method gives better values for use with the K charts.

Enthalpy

Whereas much effective experimental research has been done in the field of vapor-liquid equilibria, the same is not true with respect to thermal properties. Many correlations have been presented relating enthalpy to temperature, pressure and some composition parameter such as reduced temperature, average boiling point, average molecular weight, etc. However, experimental data on the enthalpy of multicomponent systems is meager, that of Sage and Lacey [15] and Nelson and Holcomb [15] being the most significant. Since experimental data are so limited, it has been necessary for au-

Fluid Coking

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DESCRIPTION: Fluid Coking is a continuous process for upgrading residual stocks to gas oil, gasoline and by-product coke. Based on fluidized solids technique, the unit consists mainly of a reactor where coking takes place and a heater or burner vessel where some of the coke — or alternate fuel if preferred — is burned to provide process heat.

Unit operates with somewhat coarser solids than fluid catalytic cracking and uses no catalyst. Rather, small particles of coke circulate and act as heat transfer medium. Coking is done on a thin film on the fluidized coke particles within the reactor.

Hot residuum feed is sprayed through nozzles into the fluidized coke bed in the reactor. The bed is fluidized by the product vapors with the assistance of steam added at the bottom of the reactor.

Overhead product vapors pass through cyclone separators to remove most of the entrained coke, which is returned to the reaction zone. Vapors continue through a scrubber-fractionator where small amounts of heavy liquid product and coke dust are returned to the reactor as a slurry. Fractionator products are a wide gas oil cut and lighter distillate products.

Air is injected into the burner to burn enough coke to provide process heat. Net coke produced is withdrawn to maintain proper inventory. An attriter is used to keep desired particle size in the system.

FEEDSTOCKS AND PRODUCT YIELDS:

Vacuum residua with initial points as low as 600-700 F or close to 1200 F can be processed, with Con. Carbons ranging as high as 41 percent.

Major product is gas oil in the 430-1015 F range for catalytic cracking feed. The heating oil cut, after hydrogen treatment, can be used as a direct product. The naphtha is best suited as feed to catalytic reforming. Light ends yields are low. The C_4's are about 65 percent unsaturated, the C_3's about 60 percent and the C_2's about 40 percent unsaturated.

Crude Source of Feed	Los Angeles Basin			Panhandle	West Texas	Colleville	Ordonez	Hawkins	Elk Basin	South Louisiana	
Feed to Fluid Coker	Vacuum Pitch	Deasphalter Pitch	Visbreaker Tar	Vacuum Pitch	Vacuum Pitch	Vacuum Pitch	Vacuum Pitch	Vacuum Pitch	Vacuum Pitch	Vacuum Pitch	Atmospheric Residuum
Feed Inspections											
Gravity, °API	6.7	− 0.2	− 3.5	17.3	8.4	3.7	2.5	4.2	2.5	11.6	17.7
Conradson Carbon, wt. %	17	33	41	11	19	21	26	24	30	13	5
Sulfur, wt. %	2.1	2.3	2.1	0.7	3.5	4.2	4.4	4.3	3.8	0.6	0.5
% distilled @ 1000°F.	25	0	5	0	10	20	10	10	0	5	40
Pour, °F.	120+	120+	120+	85	120+	120+	120+	120+	120+	120+	100
Ultimate yields on C₃ and Coker feed											
lighter, wt. %	8	10	12	7	9	9	10	10	11	8	6
C_4, vol. %	3	3	3	2	3	3	3	4	4	3	2
C_5/430°F, naphtha, vol. %	17	18	14	21	21	20	20	19	18	21	17
430/1015°F. gas oil, vol. %	62	45	32	69	58	54	49	52	45	61	74
Coke, wt. % (gross)	21	36	48	12	20	24	30	27	34	17	8
Product Quality											
Naphtha (C_5/430) Gravity, °API	55	54	55	59	56	54	57	56	56	56	56
Sulfur, wt. %	—	1.7	0.8	0.2	0.7	1.3	0.6	0.9	0.3	0.2	0.1
Research oct. clear	80	82	—	66	78	82	77	76	77	73	73
Gas oil (430/1015°F.) Gravity, °API	17	14	15	29	20	15	17	17	17	22	24
Sulfur, wt. %	1.7	2.2	1.7	0.4	2.6	3.8	3.7	3.4	3.2	0.5	0.4
Watson K Factor	11.3	11.0	11.0	12.0	11.3	11.0	11.1	11.1	11.2	11.6	11.8

SERVICE FACTOR: 85-95 percent.

OPERATING PERSONNEL: 2 - 4 men/shift.

UTILITIES: Based on typical 10,000 B/SD unit.

Steam (1)	21,000 lb/hr
Power	1,500 kw
Cooling Water	6,000 gpm
Direct Fuel (2)	110 MM Btu/hr

(1) Assumes no waste heat boiler. About 14,000 lb/hr steam could be generated in waste heat boiler on burner flue gas.

(2) Normally coke burned in the process.

ECONOMICS: Investment varies widely, depending on capacity, location, feedstock, etc. Operating costs vary from 25 to 50 cents per barrel throughput. Product coke is worth about $5 per ton as fuel.

Hydrofining

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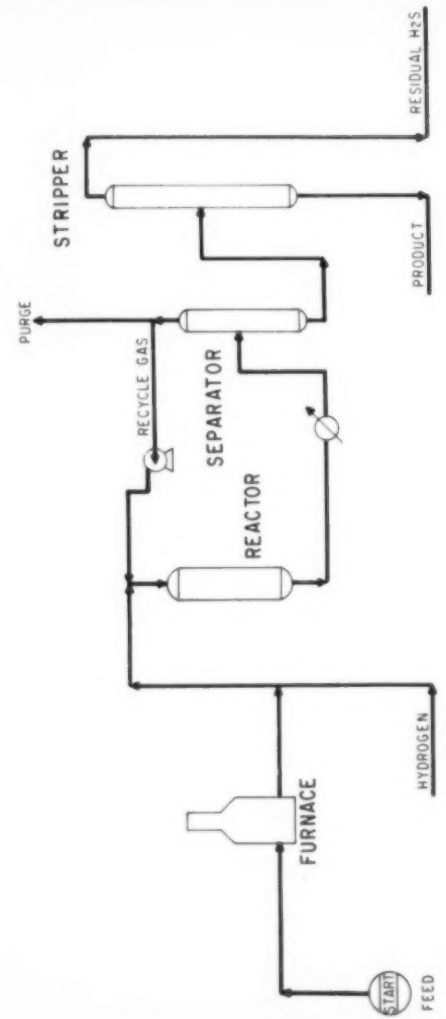

OPERATING CONDITIONS:

Temperature, °F	400 to 800
Pressure, psig	50 to 800
Feed rate, V/hr./V	0.5 to >16
Hydrogen:	
Feed to reactor, SCF/Bbl.	up to 3,500
Consumption, SCF/Bbl.	10 to 700

Hydrofining

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DESCRIPTION: This catalytic hydrogen-treating process has been applied to upgrading gas oil, diesel fuel, kerosine, virgin naphtha, solvents, cracked naphtha, heating oil, lubricating oils and waxes. Process removes impurities such as sulfur, nitrogen, and other non-hydrocarbon elements.

Feed is heated in a coil furnace to 550-800 F, depending on type and purpose of the treatment. Hot feed is mixed with fresh hydrogen-containing gas and flows to the top of the catalytic reactor. Pressure is 50-800 psi.

After leaving the reactor, feed is cooled and taken to a gas-liquid separator. The hydrogen-rich gas may be recycled back to the reactor, if desired. After separation, the liquid product is stripped to remove any residual H_2S.

Range of operating conditions employed to meet various needs are shown on the opposite side along with the flow diagram. Catalyst used depends on feedstock and process requirements. The catalysts are capable of regeneration, retain their activity for six months to two years.

FEEDSTOCKS AND PRODUCT IMPROVEMENT:

The tables below show quality improvement for Hydrofining a variety of stocks.

HYDROFINING VIRGIN NAPHTHA

Crude Source	West Texas		Middle East	
Boiling Range, °F.	200/320		200/300	
	Feed	Product	Feed	Product
Sulfur, wt. %	0.12	0.001	0.10	0.001
Mercaptan Number	33.0	0.0	18.0	0.0
Res. Oct. No. Clear	63.5	64.0	48.0	50.0
+2cc TEL/gal	75.0	81.0	64.0	70.0
Yield, volume percent	100.0			100.0

HYDROFINING CRACKED NAPHTHAS

Type of Naphtha	Light Catalytic		Heavy Catalytic		Heavy Thermal		Visbreaker	
Boiling Range, °F.	200/350		270/420		300/450		150/430	
	Feed	Product	Feed	Product	Feed	Product	Feed	Product
Sulfur, weight %	0.18	0.02	0.20	0.14	0.28	0.12	1.00	0.10
Bromine number	71.0	33.0	30.0	27.0	34.0	24.0	50.0	23.0
Res. Oct. No. Clear	88.9	85.9	90.0	90.0	59.5	53.4	71.2	63.6
+2cc TEL/Gal	94.2	93.2	95.0	95.0	70.0	69.8	76.4	75.7
Motor Oct. No. Clear	77.5	77.5	79.0	79.0	54.7	52.4	66.2	62.4
+2cc TEL/Gal	83.3	83.3	84.0	84.0	64.0	63.9	71.8	73.6
Breakdown, min. (inhib.)	75.0	375.0	465.0	1,440+	70.0	1,440.0	120.0	1,090.0
G.M. Gum (inhib.)	15.0	2.0	3.0	0.5	12.0	0.5	33.0	5.0

* Uninhibited

HYDROFINING HEATING OILS

Feed Source	West Texas (Virgin)		West Texas (Virgin)		Catalytic Cracking		Thermal Cracking	
Boiling Range, °F.	330/530		360/655		495/650		300/665	
	Feed	Product	Feed	Product	Feed	Product	Feed	Product
Sulfur, weight %	0.67	0.47	0.92	0.77	1.4	1.3	1.6	1.2
Copper Number	91.0	<1.0	92.0	<1.0	5.0	<1.0	24.0	<1.0
Carbon Residue (10% Bottoms)	0.07	0.01	0.03	0.02	0.13	0.03	0.40	0.08
Carbon Residue Blending Value					0.37	0.03	0.49	0.08
Color, Tag Robinson	24.0	20.0*	17.0	21.0	16.0	18.0	8.0	13.0

* Saybolt color

HYDROFINING CATALYTIC CRACKING FEED

Feed Inspections	West Texas Gas Oil		
	Raw	Hydrofined	
Gravity, °A.P.I.	22.3	26.2	
Sulfur, weight %	2.11	0.22	
Conradson carbon	0.9	0.3	
Nitrogen, weight %	0.20	0.15	
Nickel, ppm	0.52	0.25	
Vanadium, ppm	1.47	0.42	
Catalytic Cracking Yields			
Carbon, weight %	3.2	2.5	3.2
Conversion, volume %	48.0	48.0	55.0
Dry Gas, weight %	6.1	5.3	6.5
Butanes & Butylenes, vol. %	9.7	10.3	15.1
Naphtha, vol. %	38.5	39.4	41.1
Heating Oil, vol. %	24.7	26.3	24.5
Cycle stock, vol. %	27.3	25.7	20.5
Catalytic Naphtha Quality			
Sulfur, weight %	0.27	0.04	0.04
Res. Oct. No. Clear	93.0	93.6	94.3
+3cc TEL/Gal	97.0	98.4	98.9
Motor Oct. No. Clear	79.5	80.1	80.6
+3cc TEL/Gal	82.6	85.5	86.1
Accelerated storage stability, weeks	1.0	5+	5+

SERVICE FACTOR: 95-98 percent.

OPERATING PERSONNEL: One-three men per shift.

UTILITIES: Based on typical 10,000 B/SD unit.

Steam	12,500 lb/hr
Power (1)	250 kw
Cooling Water (25F rise) (2)	3100 gpm
Direct Fuel	50 MM Btu/hr

(1) Electric motors for all pumps and compressors.
(2) Varies widely depending on amount of preheat.

INVESTMENT: Varies with capacity, location, type and quality of feed, and purpose of treatment.

Fluid Coking

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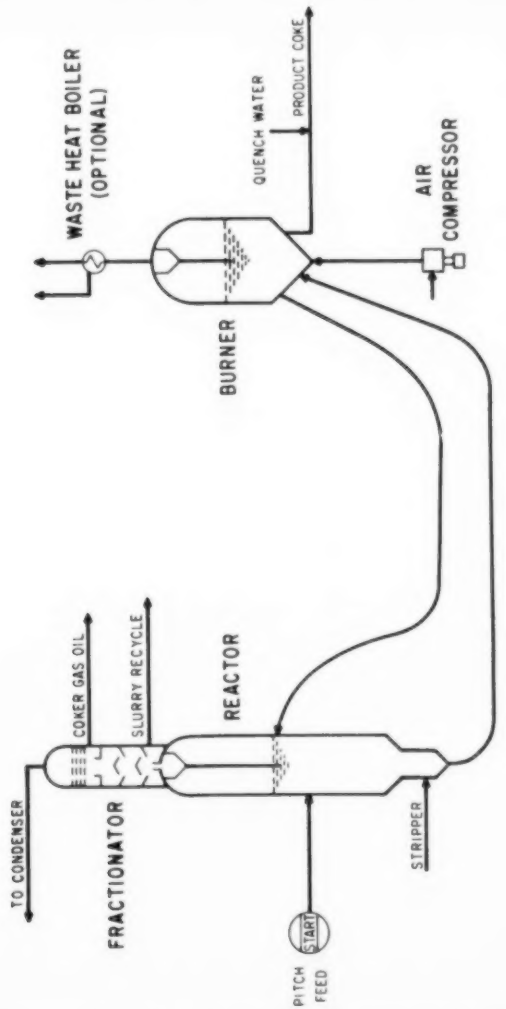

OPERATING CONDITIONS:

	°F	psig
Reactor	900-1050	5-15
Burner	1100-1200	5-15

The Refining Engineer's **Process Notebook**

thors of correlations to rely in some cases on comparisons with other correlations for tests of accuracy.

Methods of predicting enthalpies of hydrocarbon systems have been generally of two classes. Most methods [7,10,13,19] have correlated heat contents of mixtures against temperature, pressure and a composition parameter. Peters [16] presented charts for evaluation of partial enthalpies of propane and lighter hydrocarbons in which liquid enthalpies are correlated against temperature and average boiling point. Vapor enthalpies are given as functions of temperature and total pressure for each component. Canjar and Edmister,[6] and Popadopoulos, Pigford and Friend [17] have thermodynamically derived partial enthalpies from the Benedict, Webb and Rubin equation of state. Both used molal average boiling point as correlating composition parameters and used basically the same techniques. Consequently results should have been the same. While differences between the two do exist, they are not serious differences. Since the Benedict, Webb and Rubin equation has been found by many investigators to accurately predict PVT relationships for mixtures, it appears theoretically that partial enthalpy values derived from it should be valid. Again, the validity of the results has not been established by experimental measurement.

The computer program used in this study requires that heat content data be given in the form of partial liquid heat capacities and partial latent heats of vaporization. These can be determined from enthalpy data on both liquid and vapor phases. Partial latent heats of vaporization may be predicted from equilibrium K values by the use of thermodynamic relationships. This equation

$$\overline{H}_{iV} - \overline{H}_{iL} = -RT^2 \left(\frac{\delta \ln K_i}{\delta T} \right) P, N = \Delta\overline{H}_{vap} \quad . \quad . \quad . \quad (1)$$

where $\overline{H}$ is partial enthalpy, R the gas constant and T, the absolute temperature, is restricted to constant pressure and composition. Therefore in evaluating K values as functions of temperature, the effect of temperature on convergence pressure must be considered. While this effect is small in most cases, it is difficult to evaluate accurately. Also small errors in K values result in large errors in heats of vaporization. Calculation of heats of vaporization from chart K values would be subject to all of the errors of vapor liquid equilibrium, which are not known too accurately near the critical region, plus large computational errors. Thus this method of latent heat evaluation is of questionable value.

As far as accuracy of computation is concerned, it matters not whether enthalpy data are available for mixtures or partials for each component. Computer rectification programs can be satisfied by either supplying partial values for each component or by assigning each component a partial value equal to the average for the mixture. The net result, which is the mixture molal enthalpy, is the same.

EXPERIMENTAL

For a test unit, a deethanizer at the Seeligson, Texas, natural gasoline plant operated by Magnolia Petroleum Company was selected. This bubble cap fractionator was chosen primarily because of the simplicity of the system. Methane and pentane-plus components, which would have unduly complicated performance analysis, had been largely removed in preceding units. Also the operating pressure of 453 psig is in the range where greatest uncertainty exists on component properties.

The 54 in. diameter column contains 22 bubble cap trays with 38 4-in. caps per tray. Sufficient test points and instrumentation had been provided to assure adequate testing of the system. The locations of test points for determining temperatures, pressures and compositions are shown schematically in Fig. 1. Not shown are orifice flowmeters for product vapor and reflux.

Temperatures were measured with mercury thermometers which had been calibrated at the boiling and ice points of water. No heat conducting thermowell fluids were used since most of the wells are horizontal. However, since all test points were well insulated and

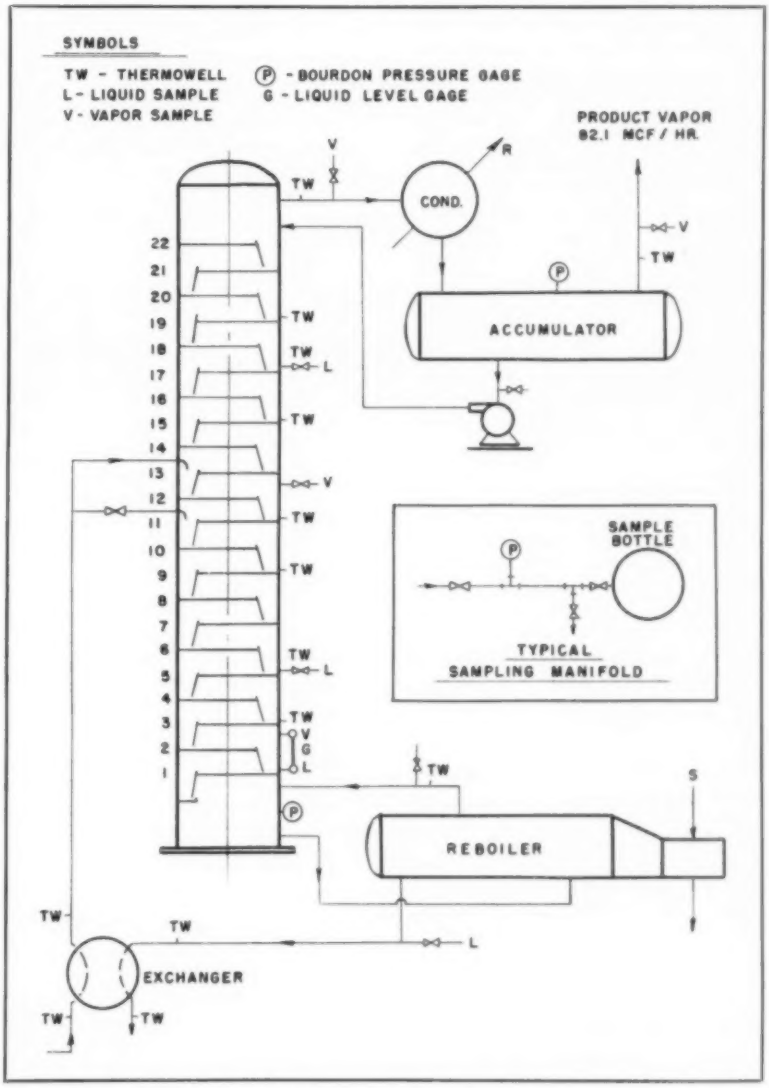

FIG. 1. Seeligson deethanizer test points.

temperatures did not vary significantly with time, it is not believed that errors resulted from this omission. It should be noted that thermowells located at the elevations of trays 3, 9, 15, and 19 are in the downcomers from the trays above. Hence temperatures taken at these points are actually those of overflows from trays 4, 10, 16, and 20.

Pressures were taken from Bourdon gages indicating pressures at the bottom of the tower and in the accumulator. The pressure recorder on the residue vapor meter gave another pressure reading.

Flow rates of ethane vapor product, deethanizer reflux, butane recirculation and debutanizer feed were determined by orifice flow meters. It was not possible to measure rates of deethanizer feed or bottoms product streams directly. However, these could be calculated from analyses and production rates of plant product streams. Production rates over the test period were arrived at by multiplying 24-hour rates, determined from stock tank gage readings, by the ratio of test period rate to 24-hour average rate of ethane product. The latter was measured directly. Unfortunately neither reboiler steam rate nor condenser refrigerant rate determinations were possible.

Liquid and vapor samples were taken by throttling to approximately 10 psig and sampling into evacuated, single port cylinders. Sampling manifolds were made up as shown in Fig. 1. In the sampling procedure, the evacuated sample cylinder was attached to the manifold. Throttling valves were adjusted with the cylinder valve closed until a steady bleed rate was established with about 10 psig manifold pressure. After thorough purging of the sampling manifold, the cylinder valve was opened slightly and the sample taken over a period of several minutes with continuous bleed off. No difficulty was encountered in vapor sampling. However, since the liquid must be completely vaporized for representative sampling, there was a possibility of fractionation using this technique on liquid sampling. Since the total mass of the vapor sample was small, the presence of liquid droplets in the sample stream would have resulted, with the technique used, in a sample with heavy component compositions greater than the stream being analyzed. This is probably the largest single cause of variation and inaccuracy in liquid composition determinations. Critical liquid streams such as reflux, feed and bottoms product were also sampled by water displacement to provide check samples.

Analyses were made at the Magnolia Natural Gas Laboratory at Dallas, Texas, using the mass spectrometer method. Since this method has been proved both precise and accurate, only single determinations were requested. Results of analyses are given in Table 1.

TABLE 1. Temperatures and Compositions of Deethanizer and Plant Product Streams.

Sample Indentification	Temp F	No samples	Composition, mole percent CO_2	C_1	C_2	C_3	i-C_4	n-C_4	i-C_5
Deethanizer feed	160.3	4	0.10	1.63	22.25	31.91	12.74	31.32	0.05
Feed*	—	1	0.10	1.45	21.78	31.33	12.94	32.40	—
Product vapors	71.2	4	0.27	6.64	81.11	11.94	0.04	—	—
Reflux	71.1	3	0.18	1.11	71.73	26.83	0.14	0.01	—
Vapor to condenser	89.0	2	0.16	3.34	76.19	20.22	0.08	0.01	—
Bottoms product*	222.0	1	—	—	2.58	36.92	17.70	42.80	—
Tray no. 2 vapor	—	2	—	0.03	13.62	52.81	10.90	22.64	—
Tray no. 2 liquid	—	2	—	—	7.70	46.39	14.49	31.42	—
Tray no. 6 liquid	184.2	1	—	—	16.27	43.89	11.80	28.04	—
Tray no. 12 vapor	164.7	2	0.18	2.19	44.60	35.05	6.26	11.72	—
Tray no. 18 liquid	126.2	2	—	0.42	30.34	66.12	1.77	1.35	—
Propane to storage	—	2	—	—	6.97	92.88	0.14	—	—
Isobutane to storage	—	1	—	—	0.28	1.12	87.63	10.97	—
N-Butane to storage	—	2	—	—	—	—	4.12	95.88	—

*Liquid sampled by water displacement.

Replication of samples made possible statistical estimates of the precision of composition measurements. Such estimates were necessary before realistic comparisons of computed values with experimental data could be made. Since there was no evidence of variation of precision with composition level (other than those compositions of less than 3 percent) the data were grouped for better precision estimates.

Separate estimates of precision were made for liquid and vapor determinations. The data supported the belief that liquid determinations were less precise. The standard deviation of the liquid determination, based on 25 degrees of freedom, was calculated to be 0.0146 mole fraction. As was expected the vapor composition standard deviation of 0.00837 mole fraction, based on 20 degrees of freedom, is significantly less than that of the liquid measurement. These estimates take into account column variations with time, sampling variations and analytical variations. It should be pointed out that these estimates are based on the assumption of random, normal variation of individuals about the average values.

Since the standard deviation of an average of n determinations is $1/\sqrt{n}$ times the individual standard deviation, confidence in results is improved through replication. Confidence limits at the 0.5 probability level (1 chance in 20 of being wrong) are given in Table 2 for vapor and liquid averages.

TABLE 2. Confidence Limits of Composition Determinations.
(95 percent confidence level)

No. Samples	Confidence Limit, Percent *Vapor*	*Liquid*
1	± 1.74	± 3.01
2	± 1.23	± 2.13
3	± 1.00	± 1.74
4	± 0.87	± 1.505

Although no check on the absolute accuracy of the composition determinations was possible, checks with the Seeligson plant "Pod" analyses of samples taken by mercury displacement were satisfactory.

Valid performance data is essential to a comparative study such as this. Consequently replicate measurements were made over a four-hour period during which no significant variations in temperature, pressure or flow rates were evident. Sufficient data were taken to provide independent determinations of several key compositions and flow rates. Consistency between the results of these independent determinations is necessary for validity and constitutes evidence of correctness of the performance data.

For a primary material balance, it was assumed that accumulator vapor, propane product, isobutane product, n-butane product and n-butane recirculation measured rates and compositions are correct. From these the rates and compositions of deethanizer feed and bottoms product may be calculated. Table 3 shows the material balance with a calculated feed rate at standard conditions of 9818 gal per hr. An independent material balance about the debutanizer, a product stream of which is the deethanizer feed, showed a 9984 gal per hr deethanizer feed rate. This balance is not shown. While the two independently determined quantities do not agree exactly, the difference of 1.7 percent is not significant.

Further independent checks on the validity of the data are shown in Table 4 which gives several independently determined compositions. The agreement, while not perfect, is sufficiently good to give confidence in the experimental data.

Boiling point and dew point checks at the measured temperatures and compositions were well within the generally considered accuracy of K value correlations used with the exception of reboiler vapor. In this case the dew point temperature was so far off (30 F)

TABLE 3. Deethanizer and Plant Product Rates.

Stream	Rate gal/hr	Rate, lb moles/hr CO_2	C_1	C_2	C_3	iC_4	nC_4	Total
Propane product	2666.3	—	—	18.24	242.84	0.38	—	261.46
Isobutane product	1364.7	—	—	0.30	1.24	97.12	12.16	110.82
N-Butane product	659.2	—	—	—	—	2.27	52.84	55.11
N-Butane recycle	2725.4	—	—	—	—	9.40	218.44	227.84
Deethanizer bottoms*	7415.6			18.54	244.08	109.17	283.44	655.23
Ethane product	2402.2**	0.595	14.63	178.76	26.32	0.09	—	220.40
Deethanizer feed*	9817.8	0.595	14.63	197.30	270.40	109.26	283.44	875.63
Deethanizer reflux	6498.4	0.861	14.96	494.26	151.29	0.73	—	661.70

*Calculated from material balance.
**Hypothetical liquid at 60 F.

and the composition differed so greatly from vapor in equilibrium with reboiler liquid that these data were discarded.

For subsequent calculations and comparisons, stream rates and compositions given in Table 3 were taken as a basis. The consistency of the data together with the recognized accuracy of methods employed warrants confidence in these values. It is believed that the composition confidence limits given in Table 2 are realistic with regard to both accuracy and precision.

Machine Computations

The IBM 650 computer program for fractionator computation requires that data be supplied on feed rate, composition and condition, product distribution (total), number of theoretical stages, heat capacities and latent heats for each component, feed stage and vapor-liquid equilibrium data. Results consist of overhead, bottoms and tray to tray compositions, flow rates and temperatures. For an existing column, this program requires an estimation of tray efficiency in order to compute column performance.

In this study the column performance was known and it was desired to determine from it the tray efficiency, equilibrium data and enthalpy variation data. Actually performance characteristics are dependent upon all of these variables and it is not possible to completely separate them. In order to arrive at conclusions concerning the variables under consideration, it was necessary to follow trial and error procedures to a large extent. It was necessary to assume numbers of theoretical stages and compute the separation resulting until agreement with test data was obtained with respect to key components. Here again a choice of enthalpy and equilibria evaluation methods was required for each tray efficiency series. This can lead only to consistency in the three variables in which compensating errors are likely. Agreement in tray to tray variations in composition and temperature should indicate accuracy of enthalpy and equilibrium data chosen.

ANALYSIS AND DISCUSSION OF RESULTS

An evaluation of existing correlations on enthalpy and equilibrium required many trial and error calculations using both a desk calculator and an IBM 650 computer. Computations on each of these variables will be discussed separately although they are necessarily interrelated.

Equilibrium Ratio and Convergence Pressure

Extensive research in the field of hydrocarbon vapor-liquid equilibria has resulted in the accumulation of much experimental data and several generally reliable correlations. However, it is recognized that prediction of K values at pressures approaching the convergence pressure is particularly uncertain. Deethanizers commonly operate at such pressures.

Equilibrium values determined from NGAA K charts, which use convergence pressure as a composition parameter, may vary depending on the method used to establish the convergence pressure. The correlations of Hadden [9] and Lenoir and White [11] do not agree for the mixtures under consideration. Hadden's method gave convergence pressures 65 to 335 psi higher than those determined from the Lenoir and White correlation as shown in Table 8. These differences result from less weight being given by Lenoir and White to the lightest component present in establishing the characteristics of the equivalent light component in the hypothetical binary. For conditions existing in deethanizer columns, these differences can have appreciable affects on predicted K values. From Fig. 2, which shows this affect on ethane and isobutane, it is seen that the relative volatilities of light to heavy components are increased with increasing convergence pressure. Thus Hadden's convergence pressure method would predict less difficult separations by fractionation.

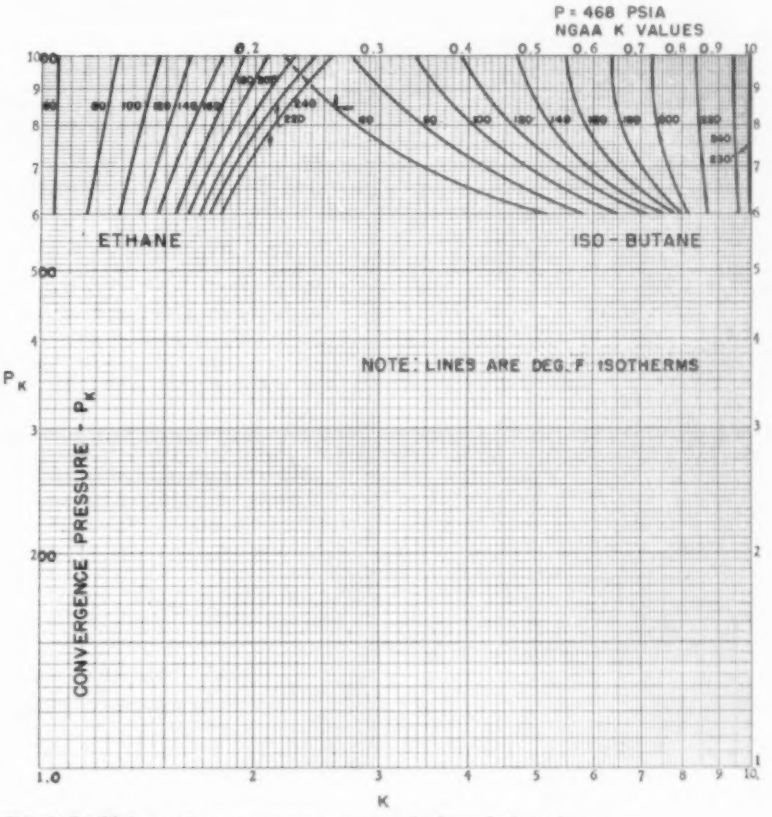

FIG. 2. Equilibrium ratio vs convergence pressure for lower hydrocarbons.

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that removes lowest-grade hydrocarbons,

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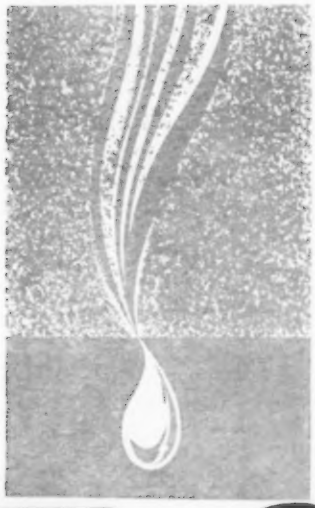

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*TRADEMARK

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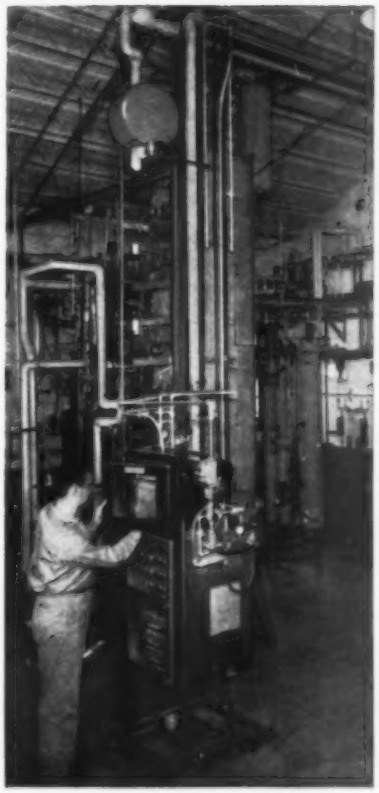

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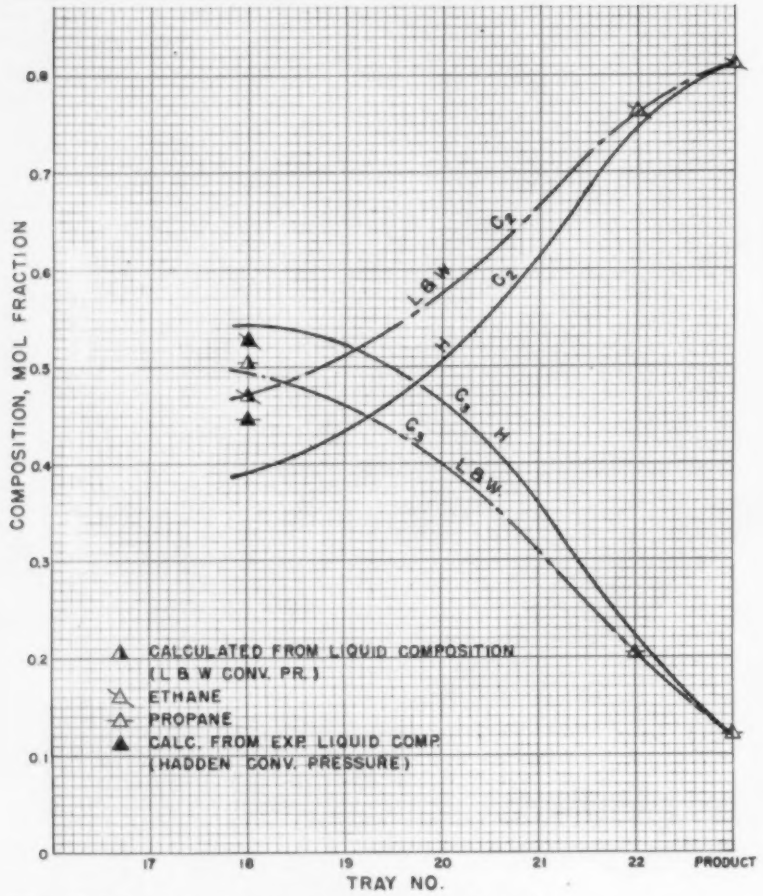


FIG. 3. Effect of convergence pressure on calculated vapor composition.

A possible method of checking equilibrium data is the tray to tray variation in composition in the upper part of the column. Here liquid and vapor rates are known and tray to tray composition changes may be calculated using each of the K value methods. Tray 18 liquid composition will afford a check on the method. Fig. 3 shows a comparison of the two convergence pressure methods. In this computation a tray efficiency of 118 percent was assumed. It will be shown later that this efficiency with Lenoir and White's convergence pressure method results in good agreement with experimental compositions throughout the column. With this tray efficiency, near perfect agreement in ethane and propane concentrations on tray 18 is obtained using Lenoir and White's method. Hadden's convergence pressure method results in wide differences between predicted and experimental compositions. While it is true that tray 18 agreement with Hadden's method could be obtained at a much lower tray efficiency, such an efficiency would result in serious disagreement further down the column. When similar calculations were made using DePriester [5] K values, significant differences between experimental and calculated values were not found.

Boiling and dew point checks throughout the system and K value checks in the accumulator showed no significant superiority among the equilibrium prediction methods studied. In fact differences in K values found were generally not greater than 10 percent and in most cases were less than 5 percent. Differences of this magnitude, however, are very significant in terms of relative volatilities and tray efficiency calculations.

Tray Efficiency

Stage efficiency referred to equilibrium between vapor and liquid leaving a tray is difficult to determine exactly. An estimate of tray efficiency must necessarily be based on definite methods of predicting equilibria and enthalpy values, particularly the former. Since average liquid and vapor rates do not vary greatly with calculation method, the enthalpy method should have little effect on tray efficiency. Plate to plate variations in efficiency are possible but unlikely.

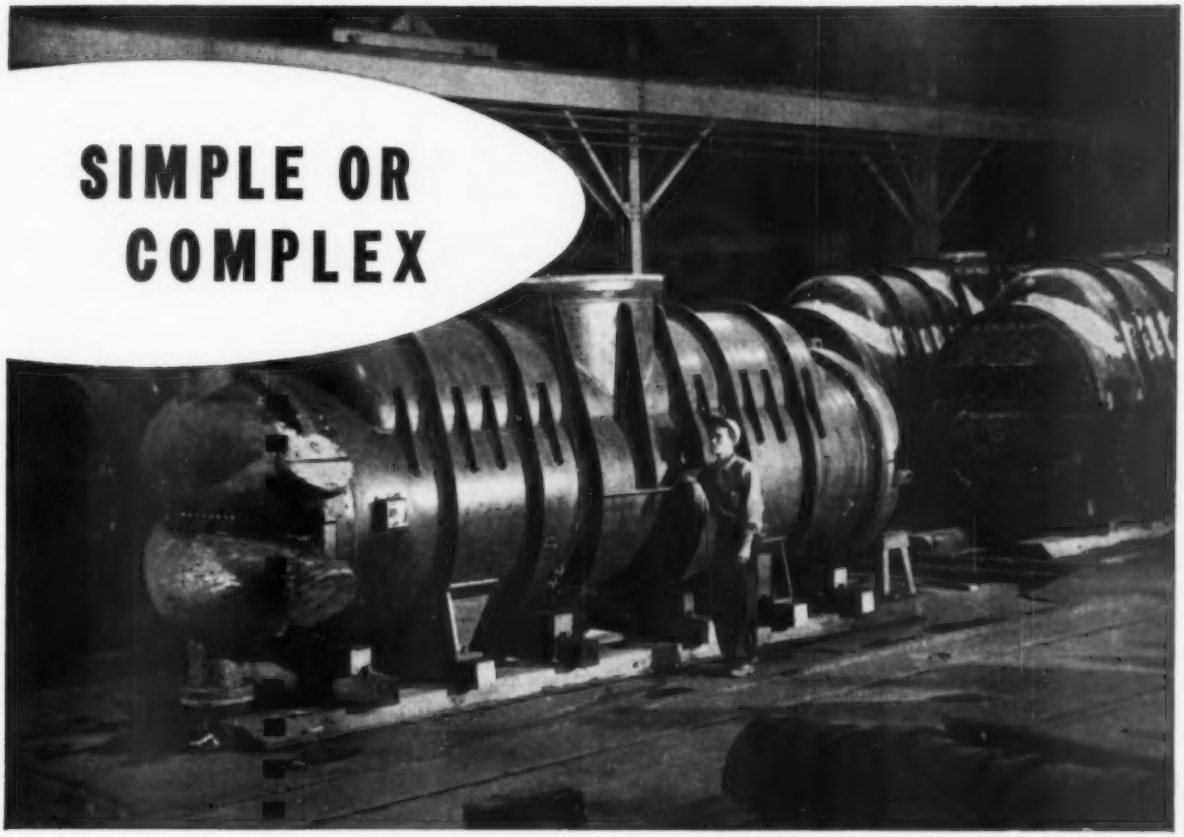
Tray efficiencies were arrived at by assuming an efficiency and calculating terminal compositions until checks were obtained with experimental data on key components. By using Canjar and Edmister enthalpy data, Lenoir and White convergence pressures and a tray efficiency of 118 percent, good agreement was obtained between computed and experimental compositions. This is shown in Fig. 4. Not only do terminal values agree but intertray compositions check surprisingly well. Almost equally good agreement was obtained with DePriester K values but at a tray efficiency of 77 percent. NGAA K values at Hadden convergence pressures indicated a still lower stage efficiency but intertray compositions were not in agreement with performance data.

The results of these computations do not constitute a basis for determining the correctness of the values obtained. Rather they show forcefully the large effect small differences in K values have on separation stage requirements.

Concentration gradients across plates which exist in columns of this size tend to make overall efficiencies greater than point efficiencies. Consequently overall efficiencies greater than 100 percent are not impossible. Vapor and liquid composition determinations were made on tray 2 of the tower which affords one check on stage efficiency. Essentially complete equilibrium between the two phases was indicated when determined by any of the K value methods. Since vapor and liquid samples were taken at the same side of the column, this indicates that the efficiency of tray 2 is 100 percent plus the increase due to concentration gradient. This evidence gives some confidence in the efficiency and equilibrium values determined from NGAA K charts with Lenoir and White convergence pressures.

The fact that good agreement with experimental data was obtained with two different K value methods but at widely differing tray efficiencies emphasizes the importance of consistency of tray efficiency and equilibrium values in performance calculations. It also points up the danger of changing equilibrium methods without at the same time making tray efficiency corrections. Thus it appears that from a design standpoint, there is a need for studies of tray efficiency with K value method standardized.

The results of operating changes on existing columns can be predicted with confidence using computer methods and existing data. This is shown by the agreement obtained between calculated and experimental values on a system operating at a high ratio of pressure to convergence pressure. Under these conditions uncertainties are much greater than at lower pressures.



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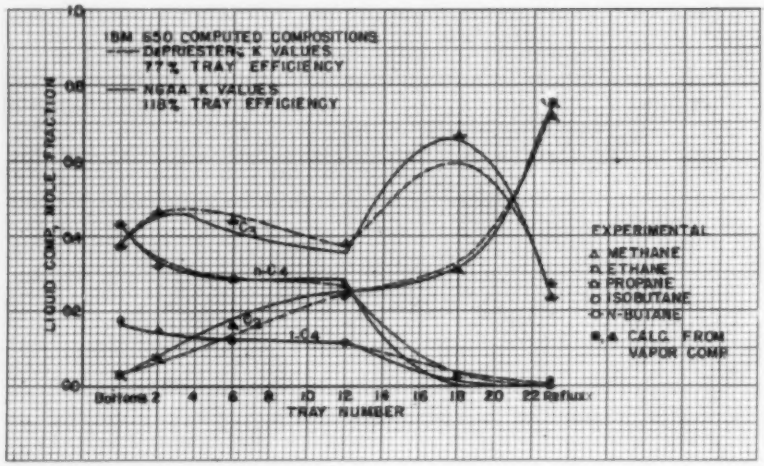

FIG. 4. Deethanizer liquid composition.

Enthalpy and Column Tray Loading

Enthalpy or heat content variations affect vapor and liquid rates in the tower, reboiler duty and condenser duty. Since data could not be obtained on reboiler or condenser heat loads, the experimental data sheds little light on enthalpy differences. However, liquid and vapor rates can be estimated from composition changes. Since these rates are functions of enthalpy, an indirect check on enthalpy correlations is possible.

Vapor and liquid rates at the bottom of the tower may be calculated from reboiler vapor and liquid composition, tray 1 liquid composition and bottoms product rate. The bottoms product rate and composition are known with considerable accuracy; reboiler vapor composition may be estimated from equilibrium calculations and tray 1 liquid composition can be estimated by interpolation between tray 2 and reboiler composition. Total and component material balances about the reboiler are given by the following equations:

$$L_1 = V_b + W \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$L_1x_1 = V_by_b + Wx_w = (V_b + W)x_1 \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Rearranging

$$V_b = W\left(\frac{x_w - x_1}{x_1 - y_b}\right) \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3a)$$

W, V_b and L_1 are bottoms product, reboiler vapor and tray one liquid respectively with x and y representing vapor and liquid compositions. From Equation 3a it is obvious that an independent vapor rate estimate can be made from a balance of each component. It is also evident that small composition errors will result in large vapor rate errors. Vapor rate calculations were made using Lenoir and White convergence pressure — NGAA K values and DePriester K values. Results of these calculations are shown in Table 5.

Although no statistical estimate of the reliability of these vapor rate values was made, it is not reasonable to believe that errors in all the quantities involved are cumulative. Rather it is probable that these random errors are partially compensating. A rough estimate of the reliability of the average vapor rate of 1316 moles per hr calculated is plus or minus 300 moles per hr.

Calculations of reboiler vapor rate from column heat balances were made using several of the more commonly used correlations. The purpose of these calculations was to determine agreement between various methods and with the estimate based on experimental data. The four correlations used were: (a) NGSMA[14], (b) Canjar-Peterka[7], (c) Peters [16] with Maxwell[13] for normal butane and isobutane components, and (d) Edmister-Canjar.[6] In order to use the partial enthalpy data of Edmister and Canjar, it was necessary to cross plot literature pressure enthalpy data to arrive at values for the operating pressure of 468 psia. These values were then plotted at constant pressure to give charts of enthalpy vs temperature with lines of constant molal average boiling point in both vapor and liquid phases. Since these authors gave no data for isobutane, a chart was constructed for this component in which vapor deviations from ideal gas and liquid deviations from saturated pure component were taken as the same as those of normal butane at equal reduced temperatures.

Reboiler vapor and bottom tray liquid rates and reboiler heat loads calculated by the various methods are given in Table 6. Liquid molar rates differ by the same amounts as vapor rates and are not given. It is seen that the vapor rate calculated from Canjar-Edmister enthalpy values is 24 percent greater than that using the Peters correlation. Reboiler heat loads calculated are in better mutual agreement.

The Edmister-Canjar correlation gives a vapor rate which is in best agreement with the experimental value. While this is insufficient proof of accuracy, this correlation also appears to be on a more solid theoretical basis than the other methods. Composition, of which molal average boiling point is

TABLE 4. Stream Compositions Measured and Calculated

Stream	Composition, mole percent CO_2	C_1	C_2	C_3	iC_4	nC_4
Deethanizer feed						
Analysis	0.10	1.45	21.78	31.33	12.94	32.40
Material balance*	0.07	1.67	22.53	30.88	12.48	32.37
Deethanizer reflux						
Analysis	0.18	1.11	71.73	26.83	0.14	0.01
Material balance**	0.13	2.26	74.59	22.85	0.11	—
Deethanizer bottoms						
Analysis	—	—	2.58	36.92	17.70	42.80
Material balance*	—	—	2.83	37.25	16.66	43.26

*Fractionator product rates and compositions assumed correct.
**Reflux rate, top vapor analysis and accumulator vapor assumed correct.

TABLE 5. Reboiler Vapor Rate Calculation.

Component	x_w	y_b*	y_b**	x_1	$\frac{x_w - x_1}{x_1 - y_b}$	V_b, moles/hr
Propane	0.3725	0.4640	—	0.432	1.86	1226
	0.3725	—	0.4637	0.432	1.87	1233
Isobutane	0.1666	0.1462	—	0.155	1.22	870
	0.1666	—	0.1483	0.155	1.74	1147
N-butane	0.4326	0.3395	—	0.360	2.91	1920
	0.4326	—	0.3282	0.360	2.28	1503
						Avg 1316

*Calculated from NGAA K values
**Calculated from DePriester K values.

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a parameter, has considerable effect on partial enthalpy in both the liquid and vapor phases. The correlation of Canjar and Petuka takes into account mixture composition and is in fair agreement with experimental data.

Variations in vapor rate throughout the column computed using two enthalpy evaluation methods are shown in Table 7. It is seen that in both cases the maximum rate occurs at the bottom tray and the minimum at the feed tray. Edmister-Canjar enthalpies result in much larger variations in rate than do Peter's values. Average rates for the two are nearly the same, 828 and 816 moles per hr respectively.

The most important conclusion to be drawn from this study concerning enthalpy is the urgent need for more reliable, precise experimental data. At present, sufficient data are not available to test the accuracy of existing correlations on hydrocarbon enthalpy. Until such data are obtained it will be impossible to design process equipment such as vapor-liquid contactors and heat exchangers closely and with confidence. Stage requirements are probably not greatly effected by enthalpy changes since average liquid and vapor rates do not vary greatly with enthalpy variations commonly encountered. However, maximum liquid and vapor rates upon which tower diameter calculations are based, are sensitive to enthalpy changes. In high-pressure columns, particularly, where costs increase greatly with diameter, large savings are possible with accurate sizing. Savings in heat exchanger investment by accurate sizing would be tremendous when considered on an industry-wide basis. Close design will only be possible when accurate enthalpy data are available. An industry-wide supported research program to secure such data should yield tremendous returns on the small investment required.

Until the enthalpy picture is cleared up uncertainties in design must be compensated for by over-design. Where applicable, the enthalpy correlations of Canjar and Edmister are recommended primarily on theoretical grounds. Since values were not given for the partial enthalpies of components heavier than normal butane, the use of these data is restricted to light hydrocarbon systems. For mixtures containing pentanes and heavier components, either the correlation of Canjar and Peterka[7] or Lyderson, et al.[12] is recommended. It was found that these two methods, which predict mixture average enthalpies, give essentially the same results. The use of pure component data, neglecting composition effects, is subject to serious error and is to be avoided in high pressure systems.

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TABLE 6. Comparison of Enthalpy Calculation Methods.

Enthalpy Correlation	Bottom tray liquid rate, moles/hr	Reboiler vapor rate, moles/hr	Reboiler heat load, Btu/hr
NGSMA[14]	1629	970	4,834,000
Canjar-Peterka[7]	1663	1007	4,783,000
Peters[16] and Maxwell[13]	1574	915	4,396,000
Edmister-Canjar[6]	1794	1134	4,509,000

TABLE 7. Computed Vapor Rates and Temperatures.

Tray no.	Vapor rate, moles/hr P-M*	C-E**	Temperature, F P-M	C-E	Measured
Reboiler	914.8	1134.1	222.5	221.4	222
1	898.8	1053.5	212.4	210.8	
2	883.4	985.2	204.8	202.5	
3	870.0	937.0	198.7	195.8	
4	854.7	900.0	193.5	190	198.8
5	841.1	869.5	188.9	185.1	
6	830.6	844.6	184.7	180.9	184.2
7	820.0	825.2	180.9	177.3	
8	808.3	808.0	177.6	174.5	
9	800.6	794.5	174.7	172.1	
10	794.8	783.0	172.2	170.2	182
11	787	756.6	170.0	168.9	
12	726.5	685.8	167.9	165.5	164.7
13	738.7	701.5	166.8	155.3	
14	752.1	718.5	158.4	146.4	
15	766.4	735.5	150.0	139.4	
16	778.8	750.0	142.0	133.8	139.2
17	788.0	759.2	134.4	129.2	
18	791.9	766.5	126.8	124.7	126.2
19	796.9	771.0	118.1	118.2	
20	813.0	790.0	107.7	109.9	117
21	839.8	824.0	95.7	93.2	
22	882.5	882.5	82.9	82.8	89
Accumulator			69.8	70.1	71

*Lenoir and White convergence pressures, Peters and Maxwell enthalpy values.
**Lenoir and White convergence pressures, Canjar-Edmister enthalpy values.

TABLE 8. Boiling Point and Dew Point Checks.

Sample	Temp, F	Convergence Pr. Lenoir & White	Convergence Pr. Hadden	y/K Lenoir & White	y/K Hadden	Kx Lenoir & White	Kx Hadden
Residue vapor	71	790	1000	0.9935	0.9884		
Reflux liquid	71	800	1000			0.96073	0.9904
Top vapor	89	790	1000	0.9520	0.9558		
Tray 18 liquid	126	815	1150			0.9858	1.0289
Tray 12 vapor	164.5	825	1000	0.9702	0.9828		
Tray 6 liquid	184	780	780			1.001	1.001
Tray 2 liquid	205	665	740			1.0087	1.0112
Tray 2 vapor	205	665	740	0.9924	0.9963		
Reboiler liquid	222	660	725			.9864	.9952

Acknowledgment

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Several factors make fractionator improvements very attractive. First, demand and stronger prices for LPG will pay out facilities that appreciably raise recovery. Second, with the increase in special service pipelines to handle only natural gas liquids, product specifications become more important.

Today, product values and demands are making good control of deethanizing and LPG separations more essential. Automation methods can be used to improve fractionation in natural gasoline plants.

Adapted from a paper presented by the author to the Permian Basin meeting of the Natural Gasoline Association of America, at Midland. Permission of the NGAA to publish this paper is gratefully acknowledged.

Cascading Controls

Fractionator design has already included control methods that were applicable. New units often have such features specified. However, existing equipment can incorporate them when the demand for more exact control justifies.

Control instruments may be cascaded —that is, the output signal from one instrument will reset or override the controller in another system. An example of cascading is found in Fig. 1. The withdrawal of kettle product is regulated by the liquid level controller, which resets a flow recorder-controller on the stream. Abrupt changes in flow are avoided so that accurate measurement is possible. Another example is shown in Fig. 2. The flow of steam to the reboiler is controlled primarily by the temperature recorder-controller to maintain a desired tray temperature. In addition, the reflux accumulator liquid level controller can reset the above controller in order to keep the level in that vessel within necessary limits. This will reduce the attention required from the operating personnel.

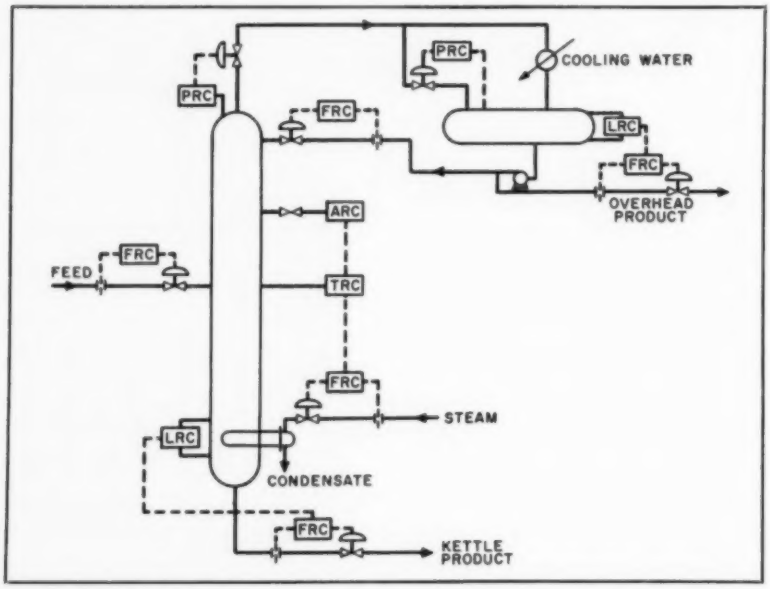


FIG. 1. Fractionator controlled by stream analyzer.

Transmitters

Transmitters to send a pneumatic signal to the recorder are sometimes preferred over direct-connected systems. Condition which make them desirable are:

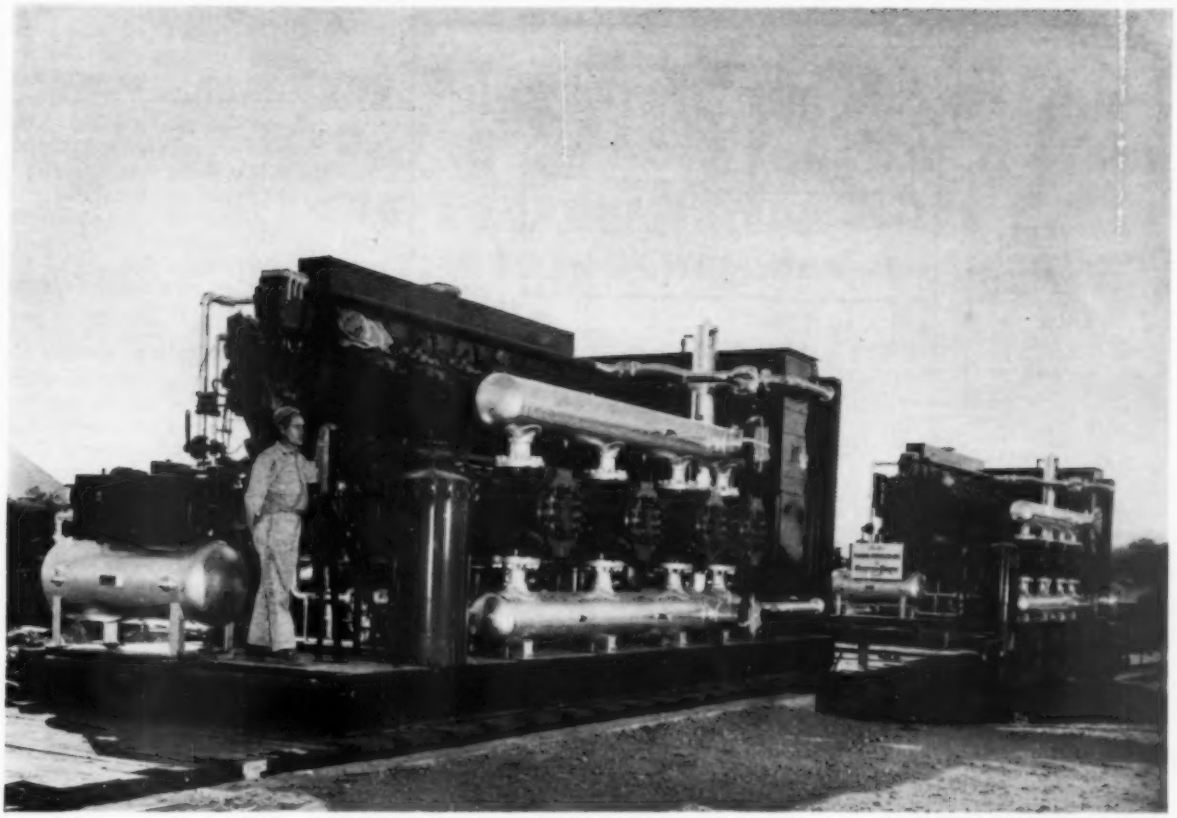
1. Central control panels with increased transmission distances,
2. Desire to keep hydrocarbon materials out of control room piping,
3. Streams which may freeze or plug off in long lead lines,
4. Faster, more sensitive response than tube systems of direct-connected temperature and pressure recorders,
5. A selected, narrow range may be transmitted, giving more accuracy and sensitivity in recorder-controller.

Stream Analyzers

Some newer advances in automation can be adapted to fractionator control. Two coming into use are continuous stream analyzers and computing machines. While prior applications of such methods have generally been limited to more precise separations in refining units, some gasoline plants are beginning to use them.

Stream analyzers may measure some physical property or may actually determine the amount of one or more hydrocarbons in the stream. Vapor pressure is a common specification of natural gasoline and many plants control their fractionators to meet a certain vapor pressure requirement. An instrument is available to measure the vapor pressure of flowing natural gasoline streams.

Instruments are being used which determine the composition of natural gasoline streams by infra-red or by chromatographic analysis. These methods work especially well when the stream under analysis is made up of



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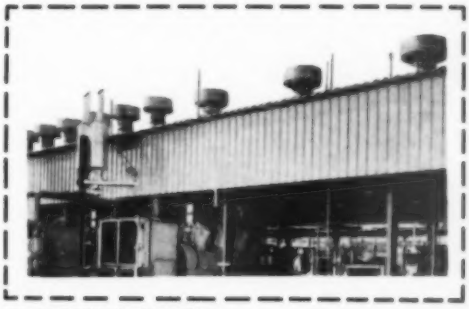

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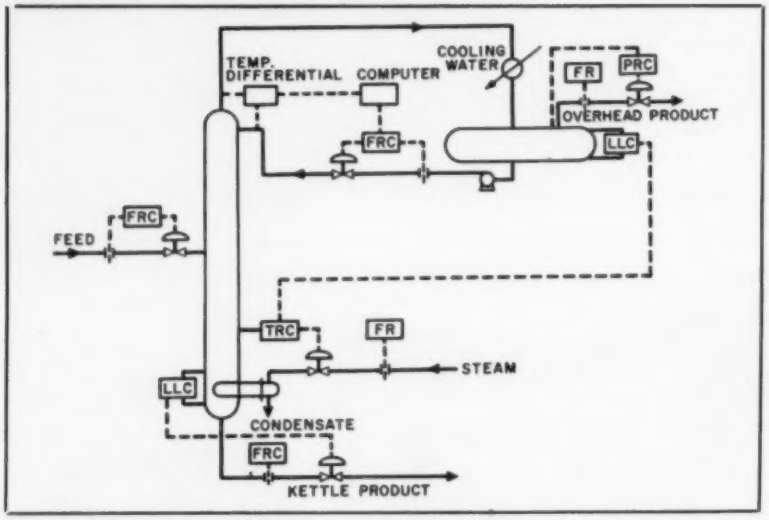

FIG. 2. Computer system to control reflux to deethanizer.

LPG components. The relatively small number of components makes the desired analysis easy with little of the interference that occurs with higher-boiling hydrocarbons.

Since chromatography has grown so rapidly as an analysis technique, applications of these instruments to fractionators will be considered. The first step usually is to install the instrument to record only. This monitoring service may give enough information to aid the operator in improving control, and can also reduce the number of control tests.

A chromatographic analyzer was recently installed on a natural gasoline deethanizer in West Texas to analyze the kettle product stream. Observation showed the ethane content to vary widely. This was surprising since it had been possible to select conditions which would give monthly composite samples with the desired ethane content. With the record of the analyzer, the operators are able to adjust the fractionator conditions to give much steadier control of the ethane content.

The final step in the application of stream analyzers is to place the instrument directly in the control system of the fractionator. A chromatographic analyzer has been used to control a natural gasoline debutanizer. To utilize the results of the intermittent analyses from the analyzer, a special peak reader was developed to provide a continuous signal for the control system.[1] A schematic diagram of the fractionator control system is shown in Fig. 1. The separation is adjusted by changing the steam input to the reboiler. The selected temperature of the control tray is maintained by having the temperature recorder-controller reset the steam flow recorder-controller. The analyzer receives a sample from the upper section of the tower and determines the amount of isopentane. The signal from the analyzer readjusts the selected control tray temperature. The cost of the analyzer and recorder with its sample system is $7000 to $9000.

[1] Fourroux, M. M., "Monitoring and Control with Automatic Chromatographic Analyzers," *Oil and Gas Journal*, April 21, 1958.

Computer for Reflux Control

Machine computing devices are often considered for complex operations. Computing principles can also be used in simple forms to aid in natural gasoline fractionators. An application has been developed to successfully maintain a constant internal reflux by compensating for the extra condensation that occurs from sudden cooling of the reflux liquid. The computing step is to use changes in the difference in the temperatures of the tower overhead vapors and the reflux liquid to calculate the correct amount of external reflux to be returned to the tower. A system designed for a deethanizer installation is shown in Fig. 2. Thermocouples are used to produce a temperature differential which is converted to a pneumatic signal. This output enters the computer which produces a signal to reset the reflux flow recorder-controller. The computer is made up of pneumatic components which are available from an instrument manufacturer. The cost of the computing system is approximately $1500. Applications of this system to several fractionation separations have given more stable operation as reflected by steadier reboiler heat inputs and product rates. ★ ★ ★

Technical Writing—Trial or Tool?

John L. Kent
Advertising and Public Relations Manager
Datex Corporation
Monrovia, California

Engineers faced with the necessity of writing a technical paper or article usually encounter obstacles, not from the subject matter concerned, but with mechanics of translating ideas into a concise written presentation.

At this point, the engineer could borrow from another technician, the professional writer, with the goal of producing a technical article which is well-knit, taut and readable. Professional engineers should not be satisfied with presenting their work amateurishly.

The greatest writing hazard to the non-professional writer is the start. Most engineers dread the prospect of producing an article or report because they are unfamiliar with writing techniques, and feel inadequate. Or, criticism of previously written articles may have left unhappy memories.

Once mentally committed to producing an article, the engineer may lose his idea by postponing too long the actual writing. Professional writers advise putting down prospective outlines and thoughts on paper at the outset. Then, a delay in writing the article can be desirable, giving thoughts time to jell.

Trial and error will show the individual the approach to make writing easier for himself. A writer's straining over his work will exhaust him, but will not necessarily improve his article.

Most important is the engineer's attitude toward his subject. If he's not sold, he can't expect to sell the reader. Material produced by a bored writer will be boring.

On the other hand, an enthusiastic approach will aid the engineer in his writing, help him derive greater satisfaction, and insure that the reader will regard time invested in reading the result as well spent.

Adapted from a paper presented by the author to the 1959 Institute of Radio Engineers National Convention.

Reprints of Mr. Kent's "How to Write Better Technical Articles," from the March, 1957, THE PETROLEUM ENGINEER, are available upon request.

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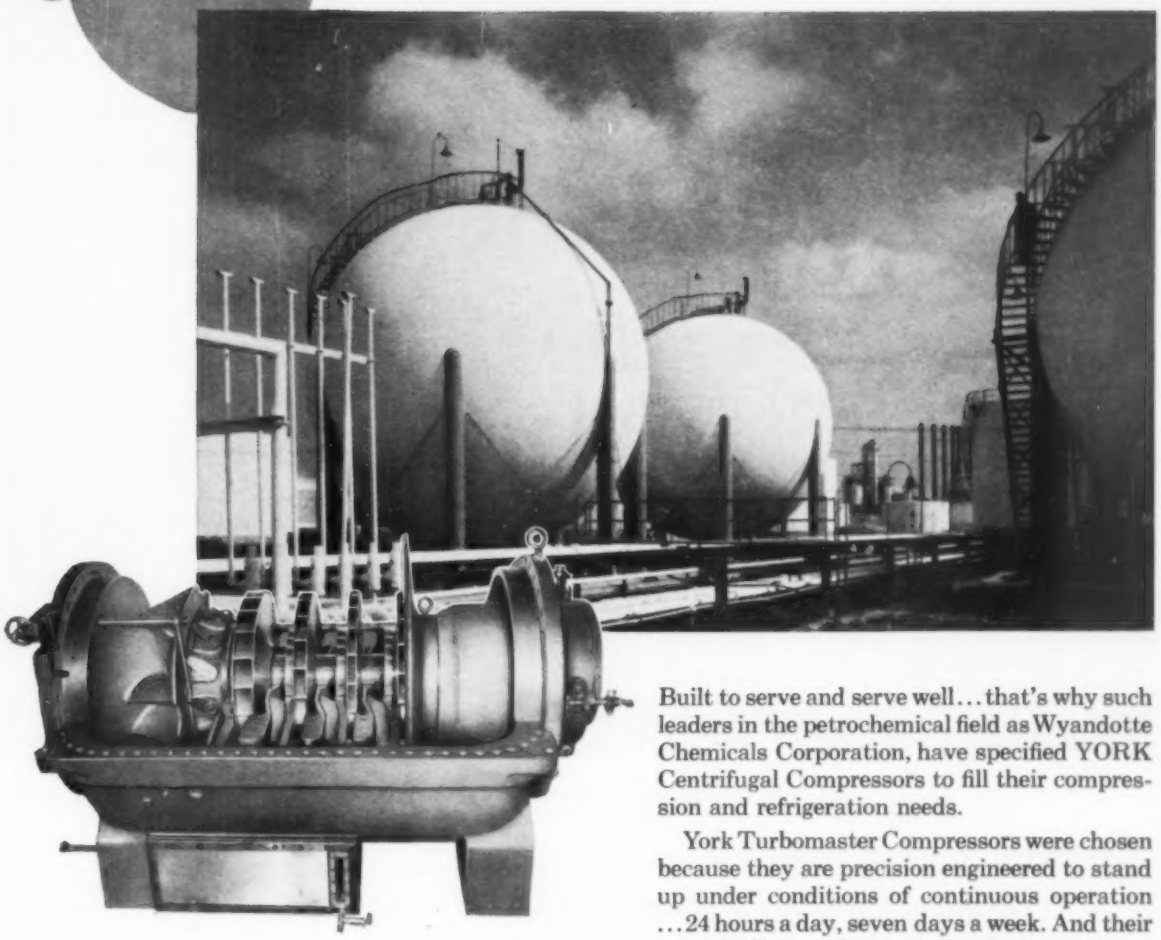

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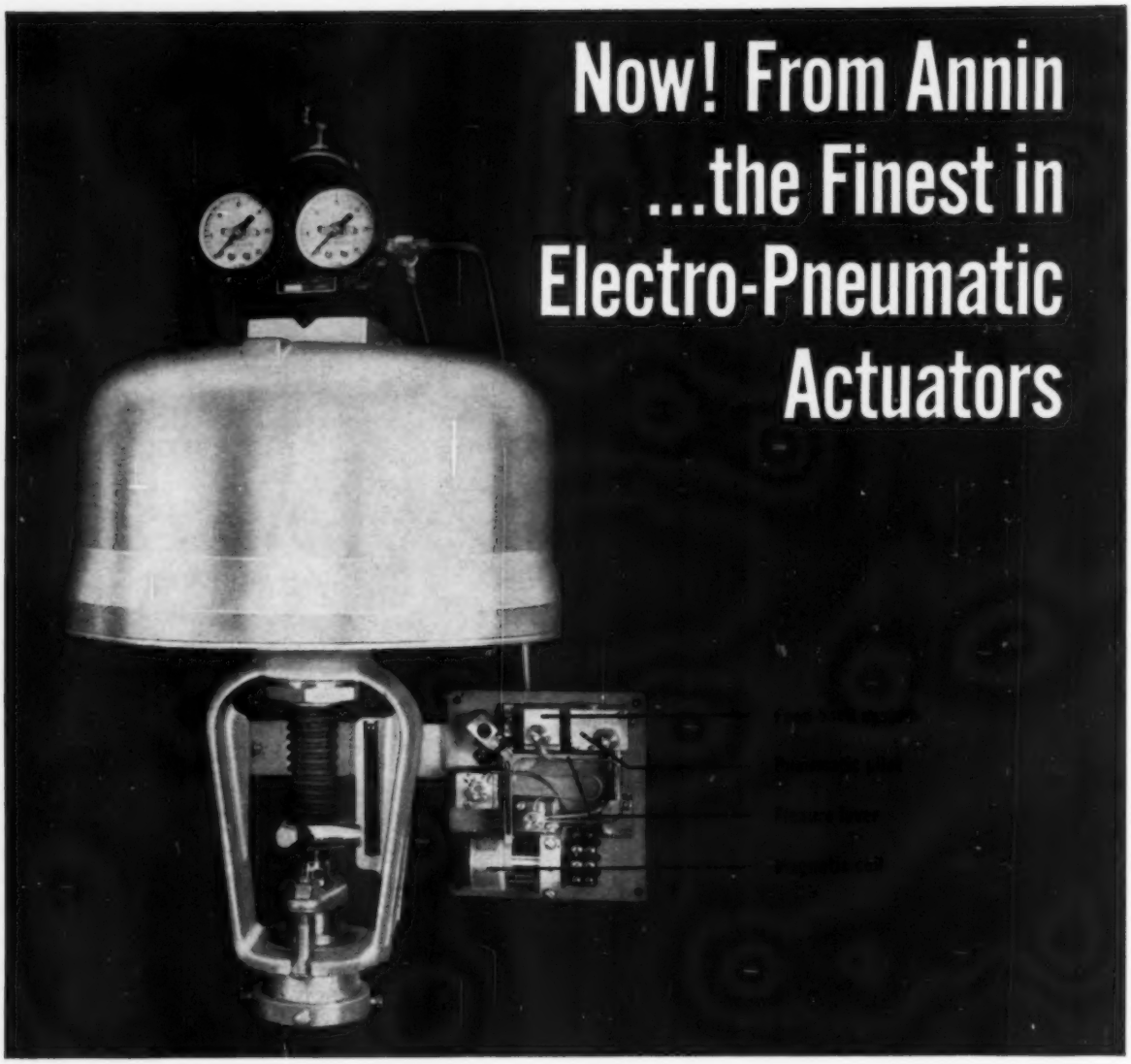

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DISTILLATION . . .
in View of Modern Developments

a series on recent developments in distillation and absorbtion techniques

PART I: Phase Equilibria and Thermodynamic Concepts
CHAPTER 1A — Phase Equilibria . . . Binary Systems

Kenneth F. Gordon and **James A. Davies**
University of Michigan, Ann Arbor, Michigan — *The Texas Company, New York City*

PHASE EQUILIBRIA

AS IS OFTEN THE CASE in many areas of chemical engineering, the main tools of a distillation and absorption column designer are the heat and mass balances plus the equilibrium relationships. The mass balances are normally straight forward in principle though tedious in practice. Minor components for which equilibrium relationships are not established may often be readily handled in design calculations, for usually they tend to go out almost completely in the overhead or bottom stream. Exceptions are sometimes encountered which include impurities that may not be chemically identified.

Acceptable heat balances seldom cause trouble in their estimation. These are clearly covered in a number of well known texts.[1, 2, 6, 7] The heat or enthalpy of mixing in hydrocarbon systems is usually small compared to the latent heat and may be neglected for the purpose of heat balances. Generalized corrections for the effect of pressure on the enthalpy of liquid and gases are available.[4] Only in a relatively few systems are the complete enthalpy data available for mixtures of two or more components. The estimation of the equilibrium relationship is much more trying. Often data are lacking for systems that include non-hydrocarbons such as may be found in gas fields. A number of thermodynamic concepts are valuable and will be reviewed in this series.

To understand fractionation properly a clear comprehension of binary and ternary phase diagrams must be had. This is especially true where abnormalities exist such as azeotropism.

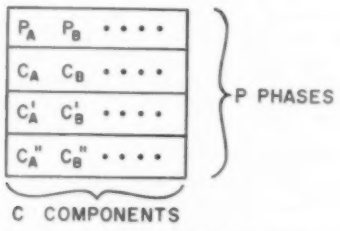

FIG. 1. Distribution of C components in P phases.

PHASE RULE

This famous law of J. Willard Gibbs provides the basis for the understanding of equilibrium relationships between phases. The derivation is straight forward and worth following.

Consider a system of C components and P phases, solid, liquid and gas, in equilibrium as shown in Fig. 1. To define a single phase at a given total pressure and temperature, it is only necessary to specify $C-1$ concentrations or mole fractions, the concentration of the non-specified component being obtained by difference. To completely define the P phases, it is necessary to have relationships for $P(C-1)$ variables and define two intensive variables, usually temperature and pressure. That is, the number of variables, N_v, is $P(C-1)+2$. For each component there must exist

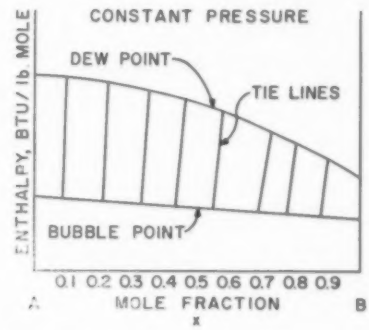

FIG. 2. Ponchon diagram.

$P-1$ equilibrium relationships between the P phases yielding for the number of constraining equations, N_c, equal to $C(P-1)$ for C components. The number of independent variables, N_i or F, which can arbitrarily be set by the designer is given by

$$N_i = N_v - N_c$$
$$= P(C-1) + 2 - C(P-1) = C + 2 - P$$

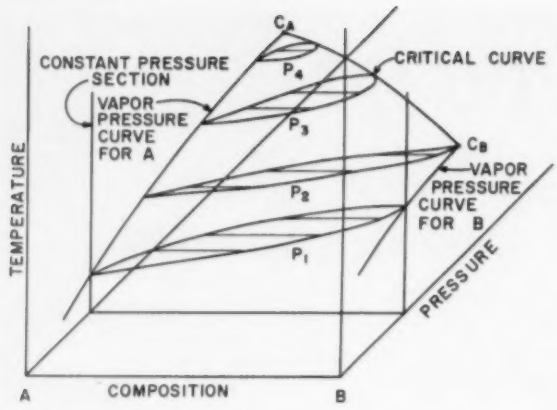

FIG. 3. P—T—x diagram.

NOMENCLATURE

C Number of components
c Concentration
F Degrees of freedom in phase rule
P Number of phases
N_c Number of constraining equations
N_i Number of independent variables
N_v Number of variables
T Temperature
V Volume
x Mole fraction liquid phase
y Mole fraction vapor phase

Subscripts

A, B Component

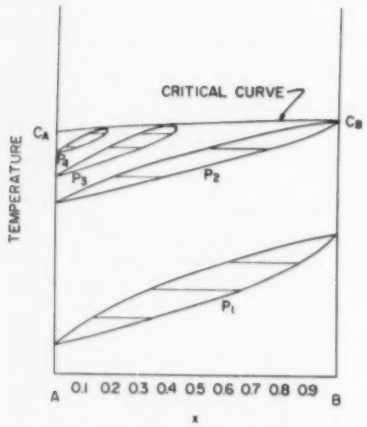

FIG. 4. T—x diagram from Fig. 3.

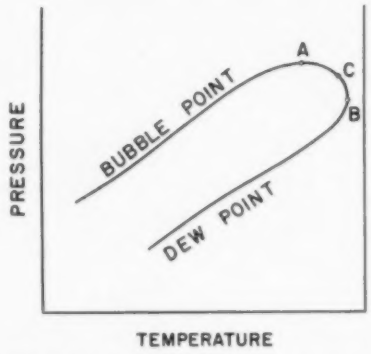

FIG. 5. P—T diagram for constant composition binary.

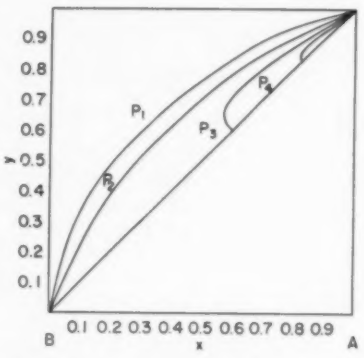

FIG. 6. y—x diagram from Fig. 4.

or in more familiar notation

$$P + F = C + 2$$

Reference to this rule will be made to aid in an understanding of complex situations.

BINARY EQUILIBRIA

There are two usual ways of graphically showing binary phase equilibria. Both are plotted at a given pressure. The more common is the T – x diagram with the temperature, T, plotted as the ordinate and the mole percent or mole fraction, x, plotted as the abscissa as in Fig. 4. The upper line on this plot represents the composition of the gas phase at equilibrium with the liquid phase and is called the dew-point line. The lower line is the corresponding line for the liquid phase at equilibrium with the vapor phase and is called the bubble-point line. The coexisting phases are shown along a horizontal line at given temperature.

The other common method of plotting binary equilibrium is the y – x diagram shown in Fig. 6. The vapor composition, y, mass or mole fraction, in equilibrium with the liquid composition, x, is plotted as the ordinate and x, mass or mole fraction, is plotted as the abscissa. This diagram is used in graphically solving binary fractionation problems by the McCabe-Thiele method. A modification is used in several shortcut methods for multicomponent fractionation.

Another method of plotting that is sometimes used is the heat balance diagram used in the Ponchon or Ponchon-Savarit method for binary fractionation.[1,6] The ordinate is the molal enthalpy and the abscissa is the mole fraction. The upper curve is the dew-point and the lower curve is the bubble-point line. The coexisting compositions must be shown by tie-lines connecting a particular dew-point composition with the bubble-point composition in equilibrium with it. A typical Ponchon diagram is shown in Fig. 2.

A complete representation for a binary system is given by a pressure-temperature-composition three dimensional diagram shown on Fig. 3. This figure shows only the vapor-liquid portion of the equilibrium diagram from above the triple points to the critical curve. The system shown is typical for hydrocarbons with the more volatile component, A, having a critical point at a higher pressure and a lower temperature than the critical point for the less volatile component. This diagram does not show the maximum critical pressure that usually exists in hydrocarbon systems. Corresponding T –x and y – x diagrams are shown on Fig. 4 and 6 respectively.

It may be noted from these curves that at low pressures the vapor-liquid curves are farther apart indicating easier fractionation. With increasing pressure the curves become closer and the fractionation becomes more difficult.

Critical Phenomena

Fig. 3 shows a common type of critical curve. However, the more volatile component may have both a higher critical temperature and pressure than the less volatile component or there may be some other combination. These will give

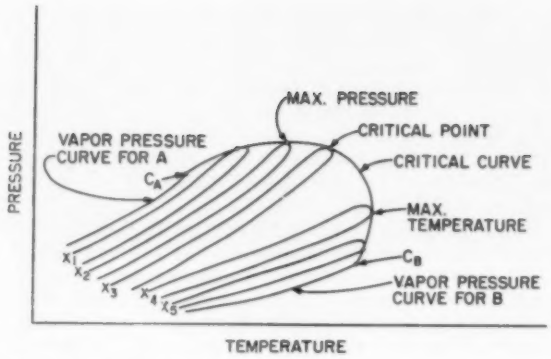

FIG. 7. P—T diagram.

somewhat different curves than shown on Fig. 4, but they can be easily developed.

Unlike a pure substance where the maximum temperature, maximum pressure and critical occur together, a binary may have these at three distinct locations. Here the critical is defined as that point where the liquid and vapor phases are of identical composition and properties. The general case for a binary is shown in Fig. 5 where A is the point of maximum pressure, B the maximum temperature, and C the critical point which may lie on either side of A and B. Each composition of a binary will have a distinct critical. The locus of the critical points yields the critical locus or critical curve.

Systems with critical curves having a maximum pressure or maximum temperature or both are frequently encountered. To show this, a pressure-temperature diagram with constant composition curves is given in Fig. 7. For a

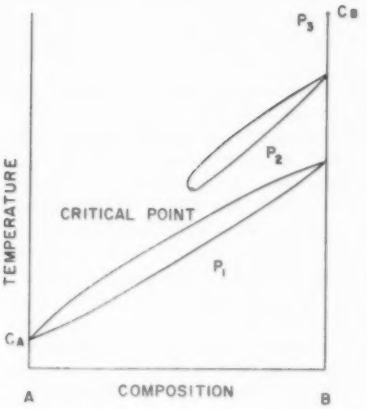

FIG. 8. T—x diagram.

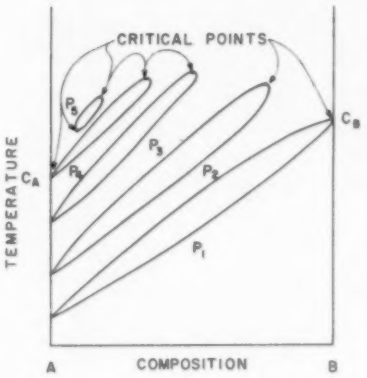

FIG. 9. T—x diagram from Fig. 7.

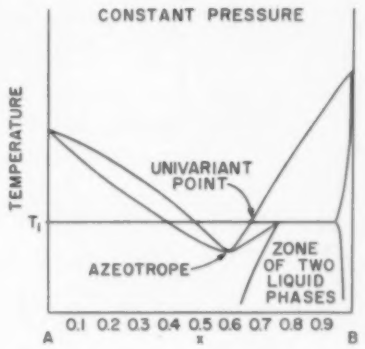

FIG. 10. T—x diagram azeotrope.

James A. Davies

Professor Gordon

James A. Davies was born in 1914 at Salt Lake, Utah, attending grade schools there, in England, and in Santa Monica, California. He received his higher education at California Institute of Technology, obtaining a BS in 1935 and an MS in chemical engineering in 1936.

He has worked with Superior Oil Company as a roustabout and then with The Texas Company in New York with the refining department's engineering group where he has been since 1936. At present, he supervises the process design of refining and petrochemical units as chief design engineer.

During the war he was a member of a subcommittee under Technical Advisory Committee that collected and reviewed operating and mechanical details of distillation systems in the petroleum industry with the aim of obtaining maximum throughputs. The committee's reports were widely distributed. More recently he is the chairman of the Distillation Subcommittee of the Research Committee of the AIChE, whose function is to follow the Institute's research program on bubble tray efficiency and to write the Design Manual for Prediction of Bubble Tray Efficiencies recently published by the Institute. He has also written a number of other articles on distillation and bubble tray design.

A member of the AIChE, ACS, ASME, TBP, Davies is a professional engineer of New York State. He lives in Scarsdale, New York.

Professor Gordon received his education at McGill University (BS English) and Massachusetts Institute of Technology where he obtained his doctorate in chemical engineering under T. K. Sherwood in 1952. As well as teaching at MIT and the University of California, Berkeley, he has been laboratory supervisor, chemical sections, Central Research, Food Machinery and Chemical Corporation.

In his present position, assistant professor of chemical engineering, University of Michigan, he teaches undergraduate and graduate courses in rate operations, thermodynamics, and mass transfer, as well as directing research in these areas. Since his arrival in Ann Arbor in 1955 he has been associated with the first AIChE research program, Tray Efficiencies in Distillation Columns, contributing to the AIChE Bubble Tray Design Manual.

He is a member of the AIChE, ACS, AAAS, Sigma Xi and Alpha Chi Sigma and a registered professional engineer in the State of Michigan. Complementing his teaching developments and research activities, he has been a technical consultant since 1952.

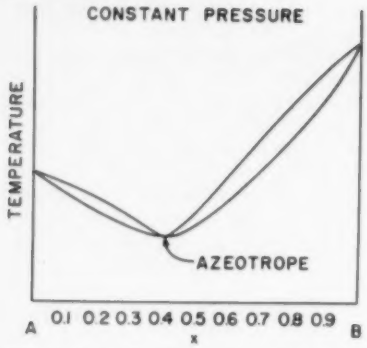

FIG. 11. T — x diagram homogeneous azeotrope.

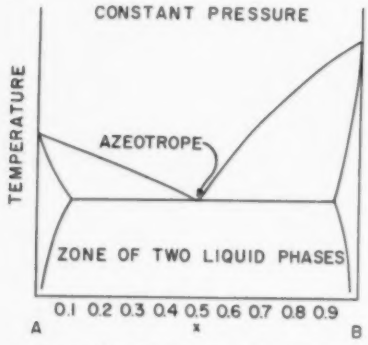

FIG. 12. T — x diagram heterogeneous azeotrope.

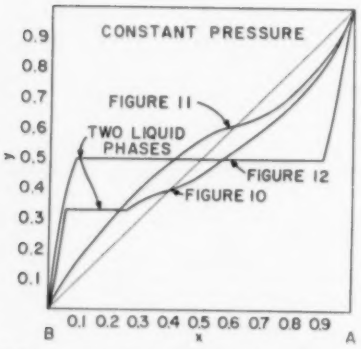

FIG. 13. y — x diagram for azeotropes.

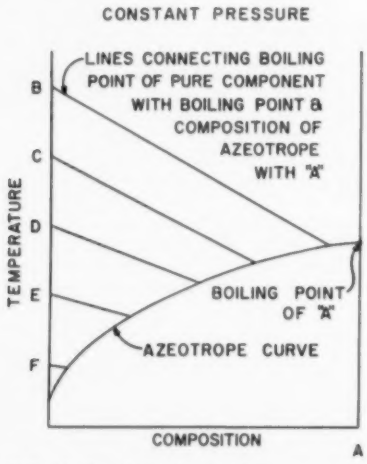

FIG. 14. Correlation for azeotropes.

constant composition the upper portion of the curve is the dew-point line while the lower is the bubble-point line. This is a similar system to that shown on Fig. 3 but with both maximum pressure and maximum temperature points on the critical curve. This figure illustrates where the critical point lies on the P-T diagram for a given mixture. Also critical curves with minimum pressure and temperature points are known. These are frequently associated with the presence of azeotropes.

Fig. 4 shows that the critical point is at the highest temperature on the T-x diagram for the type of curve shown.

Fig. 8 is a T-x diagram for a different type of curve where the critical point is at the lowest temperature. This is the type that occurs, for instance, when the more volatile component has the lower critical temperature and pressure.

Fig. 9 shows the constant pressure curves on a T-x diagram from Fig. 7. For pressures at and above the critical pressure for component A, there are two critical points for any single pressure, one at the maximum temperature, the other at the minimum temperature.

Azeotropism

When the deviations from perfect solutions are great enough, the total pressure curve for the system at a given temperature may contain a maximum or minimum point. If it is a maximum point, the deviations are said to be positive, and if a minimum point occurs, they are negative deviations. Systems with positive deviations have minimum boiling points and ones with negative deviations have maximum boiling points. The former are much more common than the latter. Also when two liquid phases of a binary exist, in accordance with the Phase Rule, a univariant point occurs and a minimum boiling point is present. The case where the azeotrope occurs when two liquid phases exist is called a heterogeneous azeotrope. When only a single liquid phase is present, the azeotrope is called homogeneous. A few systems exhibit a minimum boiling point azeotrope outside of the limits of insolubility as illustrated in Fig. 10. In this case the phase rule invariant point at a fixed pressure is not at the azeotrope temperature, but at T_1.

Fig. 11 and 12 show typical homogeneous and heterogeneous azeotropes plotted on T-x diagrams. Fig. 13 shows these systems on a y-x diagram.

A convenient method of predicting homogeneous azeotropes is given by Fig. 14[8]. This diagram gives the azeotrope composition and temperature of a homologous series of compounds with component A. The normal boiling points are given along the ordinate at zero A and tie-lines are drawn connecting the normal boiling point with the azeotrope point. As may be seen, these tie-lines are nearly parallel and azeotrope points fall on a smooth curve. It will be noted that compounds boiling much above and below component A will form no azeotrope. In predicting an azeotrope, the known azeotropes for similar compounds are plotted and the tie-lines and azeotrope curve drawn. The boiling point for the compound in question is plotted and a tie-line drawn in by estimation, similarly to the adjacent tie-line, and the point where the line intersects the azeotrope curve will give an estimate of the composition and temperature of the desired azeotrope.

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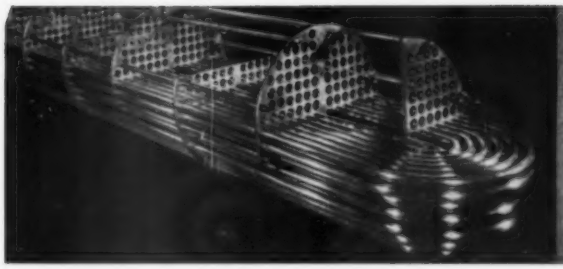

CONDENSER AND HEAT EXCHANGER CLINIC

Edited by David S. Hibbard, Metallurgical Engineer
The American Brass Company, Buffalo 5, New York

New controls and services meet increasingly critical requirements in heat-transfer units

As steam cycles in turbines become more complex—and operating temperatures and pressures rise—the job of the heat-transfer equipment becomes increasingly critical. Nuclear energy plants place tremendous emphasis on continuity of service for even conventional components like condensers. And in many processing plants the cost of shutdowns may range from exorbitant to disastrous.

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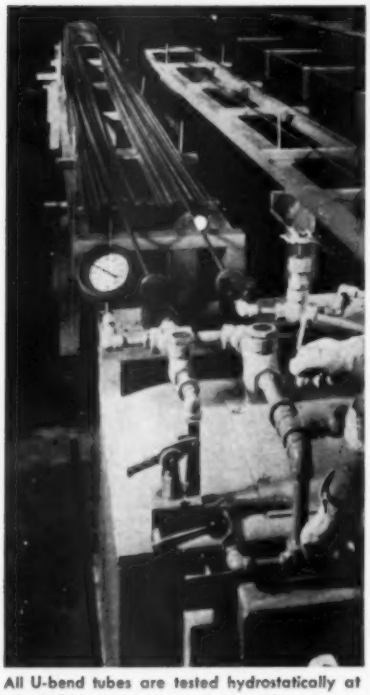

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MODERN GASOLINE PLANTS

Part 10: Design, Operating, and Purchasing Aids

Dave Vondy
Constructive Engineering Company, New Orleans, Louisiana

TO FACILITATE DESIGN AND OPERATION, it is practical to reduce available information to a readily usable form. The time and effort required to summarize data should be justified to reduce the work necessary to solve problems which frequently recur. Just as an automatic calculator can be justified for process or cost estimating calculations to reduce errors as well as to increase efficiency, design aids reduce errors.

Design Aids

The more important design aids include condensed data, approximations to facilitate preliminary work and to rough check calculations, and outlined methods and check lists.

A plot of equilibrium constants vs boiling point is a continuous line for one condition as illustrated in Fig. 55. Extrapolation to obtain the value for a heavy end component is one of the most reliable methods, but the true average boiling point should be used, which is less than the volumetric average boiling point. Also, an erroneous value for an individual component can be detected and corrected if a quick plot is made for any particular set of data. When comparative calculations are made involving a final stage of atmospheric pressure storage, it is very important that only one set of phase equilibrium data be used for the final stage regardless of how individual feed compositions are obtained.

Typical tower capacities are illustrated in Fig. 56 and 57. Typical major company economic optimum pipe diameters for short lines are illustrated in Fig. 58 and 59; since installed cost of lines in a plant is higher than that of a pipeline, optimum line size is generally slightly smaller than for short pipelines.

Although in many situations structural design should be based on elastic analysis, consideration of the ultimate failure mode of a structural member is often desirable. Perhaps the most important gain from an ultimate approach is understanding of structural failure; design generally will be improved if the designer has a better understanding of

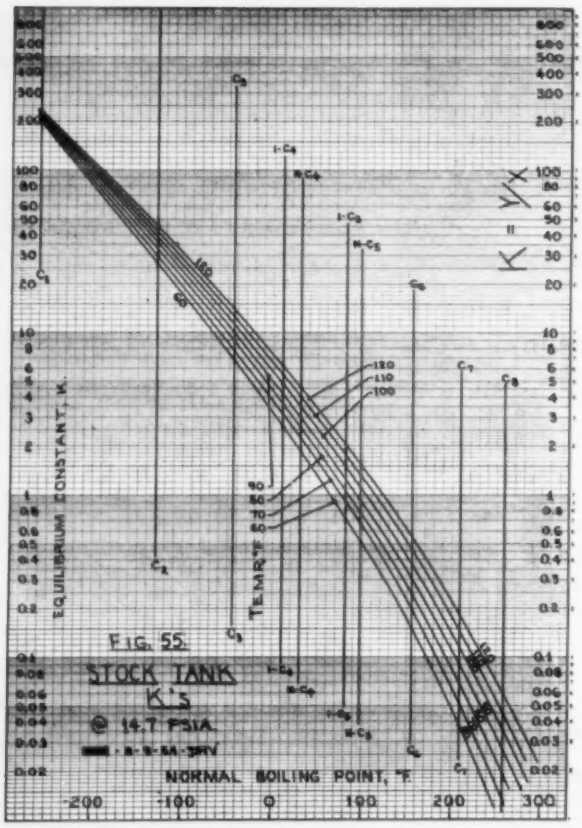


FIG. 55.

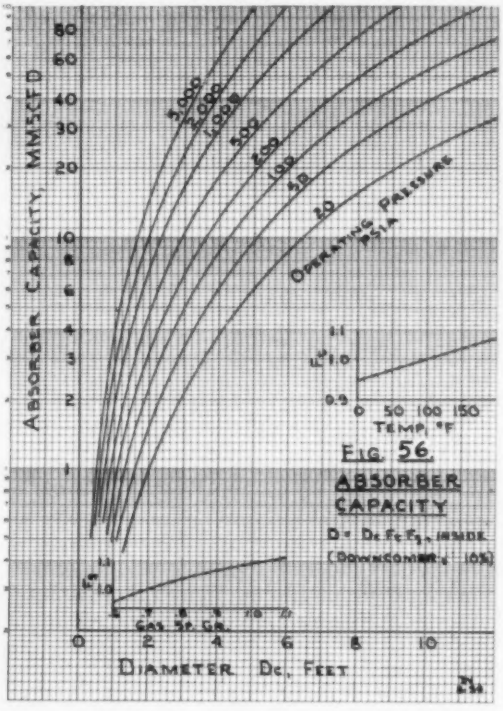
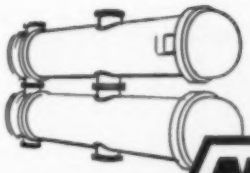


FIG. 56.
ABSORBER CAPACITY

READY TO GO . . . these heat exchangers are but a small sample of the many that continuously come off the assembly line, in various shapes and sizes, for petroleum refineries and chemical plants, at M. W. Kellogg's Jersey City shops. For promptness in service plus the optimum in design, engineering, fabrication, and cost, call Kellogg's Fabricated Products Sales Division.



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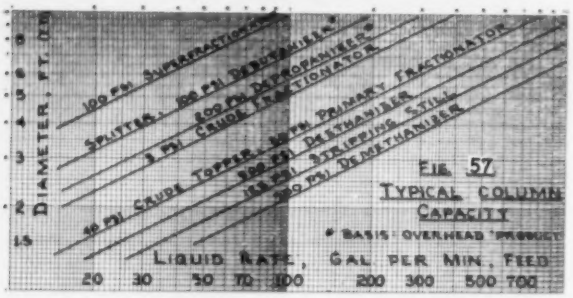
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SPLITTER, 150 PSI DEBUTANIZER*
400 PSI DEPROPANIZER*
3 PSI CRUDE FRACTIONATOR
40 PSI CRUDE TOPPER WITH PRIMARY FRACTIONATOR
350 PSI DEETHANIZER
165 PSI STRIPPING STILL
300 PSI DEMETHANIZER

FIG. 57
TYPICAL COLUMN CAPACITY
* BASIS: OVERHEAD PRODUCT

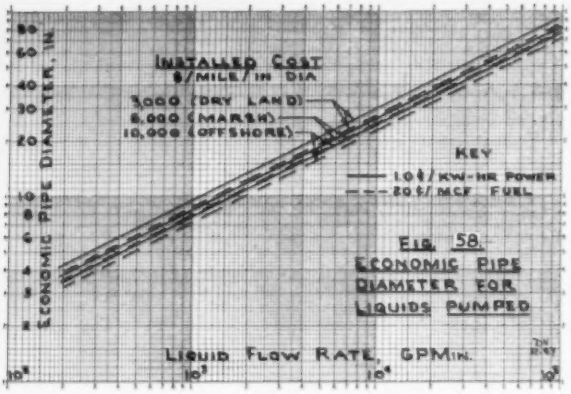

FIG. 58.
ECONOMIC PIPE DIAMETER FOR LIQUIDS PUMPED

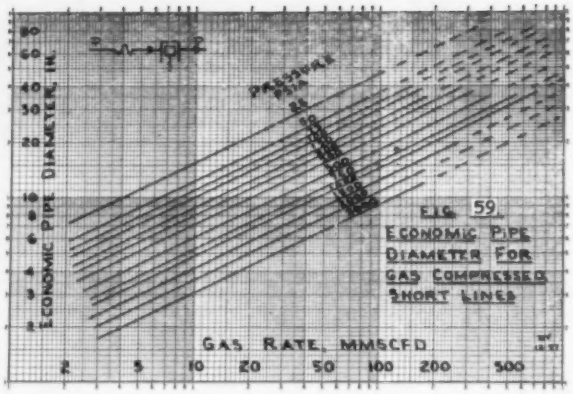

FIG. 59.
ECONOMIC PIPE DIAMETER FOR GAS COMPRESSED SHORT LINES

TABLE 1. General Check List.

Accessibility	Ownership
Buildings	Painting
Burn Pits	Piping
Chemicals	Pitch of Lines and Floors
Clean-Up	Plumbing
Construction Schedule	Power (Economy)
Consulting	Process Equipment
Contracts	Process Scheme
Controls and Instruments	Profit
Cooling Facilities	Railroad Spur
Corrosion Resistance	Regulations
Dismantling	Rent
Drainage	Right of Way and Damages
Economic Factors	Royalty
Electric (Service)	Safety
Engineering, Drawings	Salvage (Available Equipment
Equipment Rental	and Future)
Expansion of Capacity	Site
Fence	Standards, Codes
Fire Protection	Storage
Fluctuation	Structural
Foundations	Supervision and Clerical
Freight and Haul	Survey
Fuel	Taxes
Grading, Surfacing, Roads	Telephone and Radio
Guarantee	Temperature Variation
Heating	Temporary Construction
Housing	Testing
Insulation	Thermal Expansion
Insurance Requirements	Tie-In to Existing Facilities
Interference	Transportation
Labor (Economy)	Unions (Labor)
Landscaping	Unknowns (Bugs)
Layout Factors	Utilities
Lighting	Waste Disposal Facilities
Loading Facilities	Water Supply and Treatment
Maintenance Ease	Weather Factors
Operation	Zoning, Area Breakdown
Overhead	

the nature of a problem. Development of the failure mode in a simple vertical member of a support, such as might be used for a tank, pressure vessel, or other equipment is illustrated in Fig. 60. The first diagram shows a simple pinned end member, with failure occuring at one of two possible points of maximum stress due to bending moment. With the bottom of the vertical member restrained as shown in the second diagram, a structural failure does not occur when the moment at the critical section reaches maximum capacity. Additional moment imposed is carried through this point to a location where there is additional capacity, although significant deflection may occur due to the free

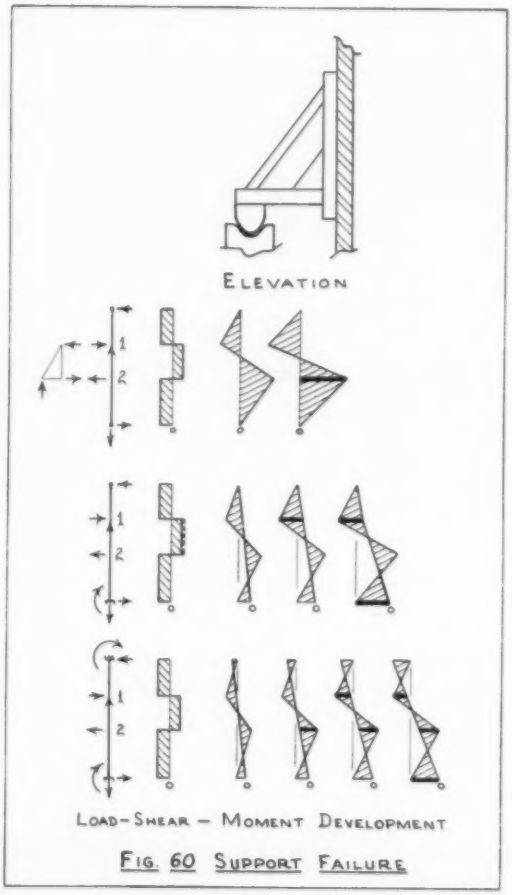

FIG. 60 SUPPORT FAILURE

1958 TOWER TESTS

Marley's 3rd Annual Report to Industry

The day of "hazard buying" of cooling towers is past. To substantiate this, Marley encourages purchasers to TEST YOUR TOWER and each year publishes the results of these tests. This list of tests is not selected or edited—it is a consecutive record of ALL tests of Marley Cross-Flow towers during 1958. Seventeen tests were conducted according to accepted test code procedure—*more than reported by all other manufacturers combined.*

TEST NO.	TYPE OF SERVICE AND LOCATION	SPECIFIED CONDITIONS				TEST RESULTS	
		Gallons Per Minute	Hot Water Temp.	Cold Water Temp.	Wet Bulb Temp.	Degrees Cold Water Temp.	Percent Capacity
1*	Petroleum Refinery—North Central	5,200	120°	84°	74°	+0.44°	+3.5%
2*	Chemical Process—Mountain States	7,000	90°	75°	65°	+0.65°	+7.2%
3*	Power Plant—West Coast	31,500	109.4°	91°	80°	+0.35°	+2.6%
4†	Petroleum Refinery—Gulf Coast	28,000	113°	93°	82.5°	+0.37°	+2.9%
5†	Petroleum Refinery—Gulf Coast	16,000	112°	91.5°	82.5°	+1.50°	+9.6%
6*	Power Plant—Mid-Central	14,750	102°	87°	75°	+0.40°	+3.1%
7	Petroleum Refinery—Gulf Coast	25,000	120°	95°	82.5°	−0.30°	−2.0%
8†	Power Plant—Mid-Central	7,000	96°	85°	75°	−0.05°	−0.5%
9*	Petroleum Refinery—North-Central	9,300	110°	84°	74°	+0.40°	+3.0%
10	Power Plant—Mid-Central	9,500	100°	86°	75°	+0.10°	+0.8%
11†	Power Plant—Mid-Central	16,000	102.2°	90°	75°	+0.30°	+2.0%
12†	Petroleum Refinery—Mid-Central	23,250	106.5°	88.5°	77°	+1.60°	+12.6%
13	Power Plant—Mid-Central	60,000	99°	84°	74°	+0.30°	+3.1%
14†	Petroleum Refinery—Gulf Coast	45,000	112°	89°	82.5°	−0.54°	−5.2%
15	Petroleum Refinery—Gulf Coast	6,000	115°	85°	79°	+0.30°	+3.6%
16	Air Conditioning—Mid-Central	4,200	96°	85°	78°	+0.30°	+3.5%
17*	Power Plant—Mid-Central	44,000	99.5°	86°	74°	+0.80°	+7.2%
18†	Power Plant—Southwest	61,500	106.5°	88.5°	76.5°	+1.20°	+11.0%
19*	Petroleum Refinery—East-Central	8,000	115°	85°	75°	+0.50°	+4.0%
20†	Petroleum Refinery—Gulf Coast	57,500	120°	85°	79°	−0.03°	−0.03%
21	Petroleum Refinery—Gulf Coast	18,830	112°	85°	79°	+0.14°	+1.5%
22†	Petroleum Refinery—Gulf Coast	34,000	113.5°	87.5°	80°	+0.12°	+1.2%

*Code Test (observer not present) †Code Test (observer present)

Here is positive proof of "in service" performance—the strongest possible assurance that Marley towers are bid and built to equal or exceed specified performance. If you believe with Marley that every industrial tower owner is entitled—if not obligated—to know the capability of his tower, before and after installation, write today for these Marley technical bulletins: "Analyze Your Bids" and "Test Your Tower."

MARLEY

The Marley Company

Kansas City, Missouri

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hinge which has developed. To cause a free mechanism in a member restrained at both ends, it is necessary that the moment capacity be exceeded at three points as illustrated in the third diagram.

Specifications for design should recognize the importance of the ultimate design approach and accept design based on this type of analysis where practical. Structural designers should become familiar with this type of analysis not only to realize benefits but also to recognize limitations.

The primary advantage of a check list is to bring to mind factors of importance which are likely to be overlooked. Bids on construction or equipment have been submitted without a profit included because the estimator became so involved in working out detailed costs that he overlooked the important requirement that a profit must normally be made on any job.

When a designer is involved in many different types of work, it is impossible for him to be sufficiently familiar with any one phase of the work to automatically bring to mind all the important factors for consideration. The general check list (Table 1) presented covers more factors than would usually be necessary for any particular job and would be abbreviated and expanded for any particular type of work. It can be used to advantage for such work as plant cost estimating or in preparation of specifications or bids. Familiarity with such a list for any use increases its utility.

TABLE 2. Work Generally Required on an Active Project.

I. Obtain Pertinent Data
- A. Scope
- B. Time factors
  1. Proposed start-up date
  2. Expected life of facility
- C. Process operating requirements
  1. Capacity breakdown
  2. Set operating conditions
  3. Product extraction and flexibility
  4. Automation limitations
- D. Material
  1. Available
  2. Availability limitations
- E. Quality of construction
- F. Accessibility and maintenance factors
- G. Instrumentation and control
- H. Corrosion requirements
- I. Utilities required and available
- J. Safety requirements
- K. Insurance requirements
- L. Federal, state, local and company regulations
- M. Contacts for specific additional information

II. Visit Site

III. Engineering Analysis
- A. Schedule work, estimate manhour requirements
- B. Economic analysis
- C. Process design
- D. Mechanical and civil design
- E. Material requirements
- F. Supplier and contractor contact

IV. Drawing Preparation (Obtain Progressive Approval and Make Drawings Available as Needed or Completed)
- A. Process scheme
- B. Equipment diagram
- C. Equipment layout
- D. Equipment
- E. Equipment selection
- F. Installation and piping

V. Prepare Specifications and Material Lists
- A. Preliminary critical items
- B. Major equipment to be purchased
- C. Material for fabricated equipment
- D. Equipment accessories including instruments
- E. Installation material and auxiliary equipment
- F. Construction specifications

VI. Prepare Operating Recommendations

Remark: A running list of decisions to be made, problems to solve and studies to be made should be kept as a check list.

TABLE 3. Cost Estimate Summary.

JOB: BY:
DESCRIPTION: DATE:
REMARKS: CHKD:

Item	*Itemized*	*Subtotal*
I. Equipment Delivered		
Process vessels		
Fractionation and reactor vessels		
Storage tanks		
Heat exchangers		
Heaters		
Compressors with drivers		
Pumps with drivers		
Other mechanical		
Buildings and structural		
Electrical		
Controls and instruments		
Pipe, valves and fittings		
Miscellaneous (with extra freight)		
Sub-total, equipment		
II. Shop Packaging		
Material		
Labor with benefits ..... manhours		
Shop overhead		
Sub-total, shop packaging		
III. Field Erection		
Construction material		
Construction facilities (all)		
Labor with benefits .....manhours		
Subcontracts (insulators, electrical)		
Field office overhead		
Miscellaneous (taxes, legalities?)		
Sub-total, field erection		
IV. Site Improvement		
V. Chemicals (catalyst, solvent, desiccant)		
VI. Engineering (with field)		
VII. Administration and Overhead		
VIII. Profit (before tax)		
IX. Contingencies		
X. Total Cost		

Note: show only dollars because odd cents are insignificant.

The outline on work required on an active project is from an engineering viewpoint (Table 2); certainly many of the factors actually overlap. The relative importance of the factors involved depends upon the particular job.

The cost estimate summary form (Table 3) presented is typical of that used by a contractor in estimating a job. Use of such a form automatically causes the estimate to be broken down in a desirable manner and avoids omission of a principle item.

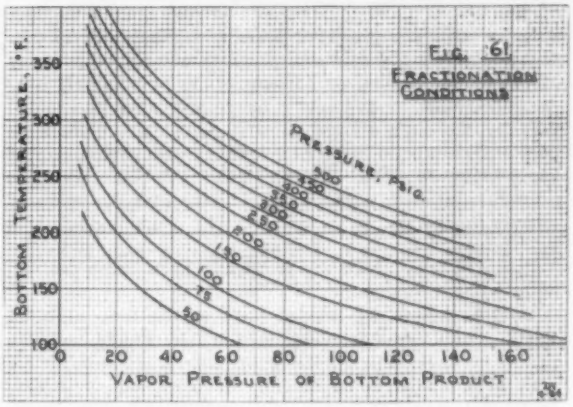
Also included is a typical check list for pressure vessels (Table 4). Similar check lists can be developed for other fabricated equipment or manufactured items when necessary.

Operating Aids

In operation, those technical aids which are of the most value present information in a simple manner easy to interpret (difficult to confuse). A good example is the information needed to calculate flow rates from orifice meter data; square-root charts have become popular not only because a universal chart can be used but also because rate calculation is simplified. But if coefficients are not worked out as simple multiplier factors to cover the range of interest, the manipulations which must be gone through for each

TABLE 4. Pressure Vessels Check List.

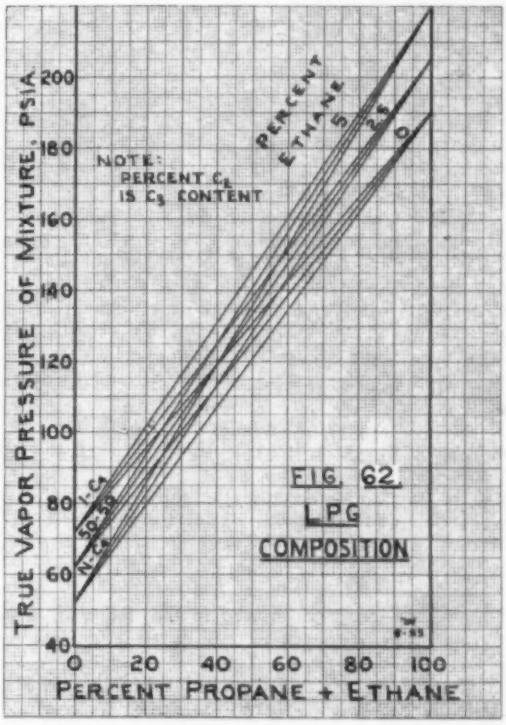
1. Heads: quantity, type, special design, material, diameter, thickness, straight flange, reinforcing.
2. Shell plate: quantity, material, thickness, dimensions, stock plate, roll capacity.
3. Base support or other mounting: loading, concentrated stress, bolt holes, special anchor bolts, openings.
4. Nozzles:
   - A. General: ASA or other rating, joint type, gasket, bolts, seamless neck (except large), 6000 psi FS coupling to 1 in. seam clearing, nozzle schedule.
   - B. Main inlet: size, location, baffling.
   - C. Auxiliary inlets: requirements, size, baffling.
   - D. Gas outlet: size, location, baffling.
   - E. Liquid outlets: size, location, baffling (vortex).
   - F. Drain: size, location, baffling, solids trouble.
   - G. Manways: size, location, access, cover, davit, utilization.
   - H. Handholes: access requirements, size, (inspection and radiographing requirements).
   - I. Level control: dimensions, clearance, remoteness, special requirements.
   - J. Level gage: size, location, special considerations, jig set dimension.
   - K. Relief valve: capacity, size, location, sealed outlet pipe or drain.
   - L. Pressure gage: size, location.
   - M. Thermometer: size, clearance, location.
   - N. Thermowells: requirements, clearance, size.
   - O. Instrument connections: special requirements, size.
   - P. Test connections: requirements, size.
5. Mist extractor: material, size, support, protection.
6. Filter media: material, size, support, protection.
7. Internals: material, location, effectiveness, access, seals, packing.
8. Ladder and/or platform requirements.
9. Lifting and guy lugs.
10. Insulation requirements.
11. Reinforcing pad requirements.
12. Welding: special requirements, detail and stagger location long seams, round-abouts, nozzle welds, weld metal load capacity.
13. Nameplate, location and stamping: shop, date, vessel identification, design pressure, design temperature, capacity, job identification.
14. General notes: code construction, stamping; outside inspection, stamping; design pressure, temperature; test pressures, time, special requirements; corrosion allowance for vessel, internals; radiographing if required; stress relieving time and temperature; bolt holes straddle centerlines; general material requirements; general welding quality, type; drain water and remove loose material; rust preventative on machined and threaded surfaces; painting or other surface coating; plug openings; vessel weight empty, operating.
15. External connections: line clearance and practical arrangement, instrument accessibility, general appearance.
16. Companion flanges, loose or special accessories and material.
17. Additional details and reference drawings.
18. Drawing number and file recording.
19. Confidential details of construction to be separate from main drawings to be released.
20. Analysis to reduce construction cost.
21. Analysis to satisfy process requirements and avoid operating trouble.



rate calculation are time consuming and there is reduced probability that accurate flow rates will be available locally.

Considerable time is required for a fractionator to reach operating stability necessary for a vapor pressure test to be accurate after a change is made in operating conditions. The desired result will require considerable time to realize if the initial change made in the operating conditions is not very nearly that needed. It is possible to predict the final conditions required relatively accurately, especially if condensed operating data on the particular hydrocarbon system is available. It is most practical to establish operating lines on a vapor pressure chart to determine conditions. Typical conditions for light hydrocarbons are shown in Fig. 61; presence of an appreciable amount of heavy ends causes temperatures to be elevated considerably.

The vapor pressure of LPG is appreciably raised by a small amount of ethane, as illustrated by Fig. 62. 75 percent more 50-50 butane is required with a given amount



of propane containing 5 percent ethane than with pure propane for a 150 psi vapor pressure mixture, and 33 percent more for a 100 psi vapor pressure mixture. Since many of the tanks installed by consumers are of relatively low-pressure design, an excess of propane may often be avoided only by thorough ethane removal from the propane. In colder areas where low winter temperatures require higher vapor pressure LPG, higher pressure storage tanks are normally installed, propane has a higher market value and ethane content is not as critical. The chart presented as based on mol percent, while being satisfactory for design purposes, is not as useful in operation as one based on liquid volume percent.

Operating aids are needed most at the time of plant start-up, and useful technical information should be made readily available. The operating staff should not be burdened with such details as calculating the capacities of miscellaneous storage and surge tanks and other vessels during the period in which a plant is placed on stream.

Generally more information is needed at a plant covering optimum operation, aids to realize maximum profit through best operation. Many aids available in design are useful in operation.

Complex operating procedures and maintenance schedules can be followed only if requirements are readily available to operators. Sealing written instructions between plastic sheets will avoid usual damage.

Specifications

The prime consideration in purchasing is that of meeting requirements at the lowest possible cost. Most economical results are realized when competitive bids are obtained on equipment or work to be done based on carefully prepared specifications. The primary role of specifications is to insure that equipment or work to be done meets certain minimum requirements.

Specifications enable required flexibility to be realized, economical future requirements to be incorporated, operating costs to be reduced, and installation of unsuitable equipment to be avoided. They further enable standardization reducing spare parts requirements and easing maintenance. To carry out their intent, they should be backed up by inspection and performance tests, and bids not meeting specified requirements should be rejected.

Responsibility for specifications generally rests primarily with engineering. However, close cooperation with purchasing is necessary to obtain maximum utility, with operations for realistic results, and with a legal representative to avoid future complications.

Specifications are frequently written in such a manner that one or more suppliers or contractors are purposely eliminated, which may or may not be desirable depending upon the particular situation. A contractor's or supplier's bid varies between purchasers, one reason being that actual requirements must be estimated from past experience.

That specifications must take into consideration the particular type of work can be illustrated by considering a piping requirement. It is generally true that a saving is realized and the completion date moved ahead by prefabricating some piping such as manifolds and valve by-pass systems. But when piping is installed in the field, each run normally must have flexibility in three coordinates; any specification written without regard for this flexibility requirement is unrealistic. That vessel nozzles be held within close tolerances and that prefabricated pipe runs be supplied to close dimensions adds unjustified cost.

Flexibility should be allowed in the design of vessels. Shell plate and heads are stocked only in particular sizes and economical usage of material is possible only if advantage can be taken of availability. Mill delivery of special material is not only costly but also requires appreciable time. Extra shell length of less than two feet will often cost very nearly as much as an additional section six feet or longer.

Appreciable saving is often possible by using new (but proved) equipment. For example, several types of unions have been found to be entirely satisfactory where interchangeability is not required, which reduce cost primarily by reducing installation labor below that required for conventional ASA flanges.

The usual practice of specifying a particular supplier "or equal" or "or approved equal" should be entirely avoided. It is better to specify first and second choices, and then clearly indicate that an alternate proposal will be welcomed but will not be considered unless a primary proposal is submitted.

Frequently it is possible to present requirements so as to challenge the supplier or contractor to find the most economical solution. Although not always feasible, such an approach, allowing the bidder to take full advantage of his particular facilities, yields best results. However, careful analysis of the submitted bids on an overall basis is usually necessary to select the most favorable.

Specifications should be straightforward with particular emphasis given in preparation toward clarity.

Acknowledgments

This series contains little if any original information, only interpretation. Use has been made of the properties of materials and other engineering data for which we are indebted to the original investigators for their tedious efforts and to the companies, schools and organizations such as A.G.A. and ASTM for their interest and support.

Acknowledgment is made to the many people under or with whom I have worked, thereby benefiting from their experience and ideas, including: Charley Barry, Jim Garritson, Bill Hayes, Steve Worley, Bill Scheirman, Bob McMinn, and so many others. The reader has benefited considerably from the editing by Whit Downer III.

Errata

It will have been noted in Part 6 that the desiccant capacity should have been on a basis of 100 lb of desiccant. ★ ★

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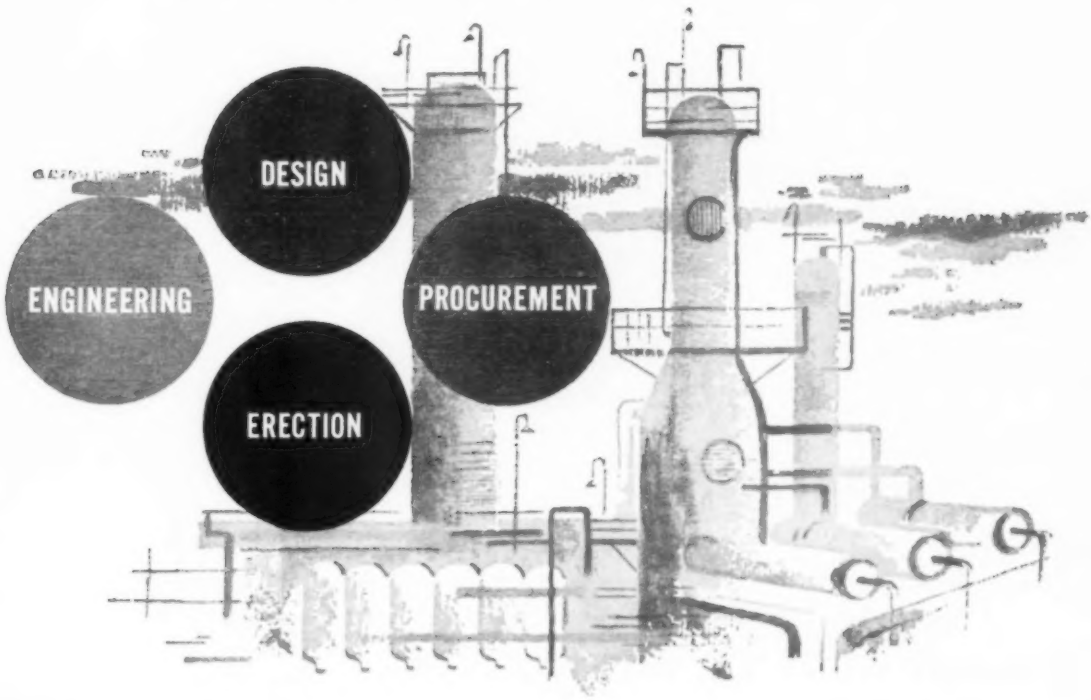

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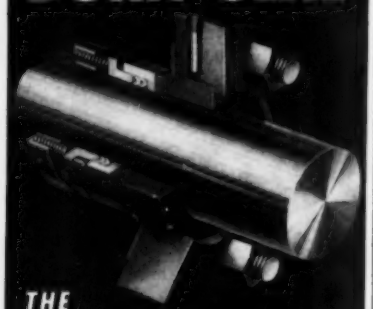

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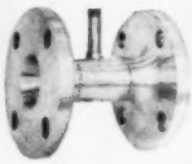
New Equipment

Turbine-type Meters

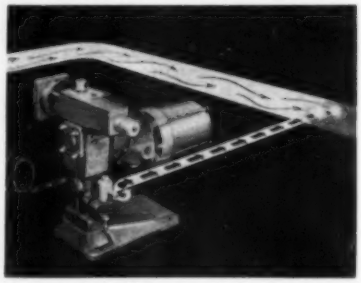
Electronic readout and control equipment is now available for incorporating turbine-type Pottermeters into remote control, remote reading or telemetering systems for handling petroleum in refinery installations. Pipe-mounting Pottermeters incorporate a turbine-rotor which generates an electrical current proportional in intensity to the flow rate. Supplied by *Pottermeter-Bowser Division of Bowser, Inc.*



Circle number (41) on reply card.

Metering Pump

Compact, packless pneumatic stroke controlled meter pump automatically proportions chemicals to any main line flow, maintaining a constant proportional discharge. Operating on a 3 to 15 psig air signal, the McCannameter requires no additional power source of air, responds instantly to eliminate backflash. Announced by *Hills-McCanna Company.*



Circle number (42) on reply card.

Meter Announced

Unsurpassed accuracy and reliability are claimed for a 16 in., 15,000 bbl per hr capacity, positive "screw displacement" meter announced by *Rockwell Manufacturing Company.* The new "Turbo-Meter" is said to weigh less than ⅛ as much as positive displacement meters of the same capacity, and cost less than half as much. Capacity is set at 15,000 bbl per hr with liquids of up to 500 SSU viscosity; accuracy of better than 15 parts in 1000; repeatibility of better than 1 in 1000.

Circle number (43) on reply card.

Cooling Tower Change

Now included as standard equipment on industrial cross-flow cooling towers made by *The Marley Company* is a new method of supporting filling splash bars with molded grids fabricated of glass fiber reinforced polyester resin. These new supports, immune to rot and decay, will increase tower service life and reduce maintenance cost.

Circle number (44) on reply card.

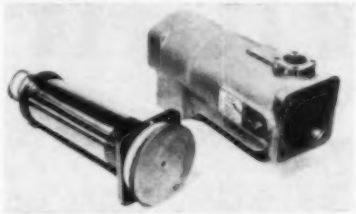
Valve Sizes Added

Three sizes--¼, ⅜, and 1¼ in.--rigid PVC Y-globe valves, check valves and strainers have been added to the product line of the *Walworth Company,* making the line complete from ¼ to 2 in.

Circle number (45) on reply card.

Flow Meter

Low cost, fluid flow-rate meters are being offered by *The Rosaen Company.* Accuracy is stable for viscosities varying from 100 to 750 SSU. Available in 5 maximum capacities, from 10 to 200 gpm, the Tell-Tale flow meter works under vacuum and pressures to 5000 psi. The low cost is attributed to its simple design.



Circle number (46) on reply card.

Foam Extinguisher

Liquid fuel fires are the special target of a positive displacement foam liquid proportioner, designed to operate from water flow in a fire line or hose, now available for industrial application after extensive military use. Available in 2 sizes, 60 to 180 gpm and 200 to 1000 gpm flow, the proportioner is designed for either 3 or 6 percent foam and is accurate over a wide range. Designed by *Hale Fire Pump Company.*

Circle number (47) on reply card.

Vacuum Pump

Pure samples of liquids (and some powdered solids) can be obtained from tanks, drums, crankcases and many inaccessible places with the "Golden Thief," a vacuum pump that draws the desired sample into laboratory bottles or cans. Distributed by the *W & W Manufacturing Company.*

Circle number (48) on reply card.

Cleansing Pistol

A Swiss-made product, introduced in this country by the *Swissair Tool Corporation,* removes rust and scale by the recoil movement of a series of hardened needles located in the pistol's head. Compressed air operates the spring action of the needles, and blows the working surface clean of removed particles. Needles operate independently, adjusting to the contour of the surface being cleaned. Needles are available in hardened steel or non-sparking copper brillium. Working air pressure is 88 psi, air consumption 12.5 cu ft per minute.

Circle number (49) on reply card.

Refining Personals

R. H. Starrett

▸ **Richard H. Starrett** has been named chief production engineer at The Pfaudler Company, a division of Pfaudler Permutit Inc.

▸ Standard Oil Company (Indiana) has announced the promotion of **John H. Johnsen,** formerly assistant manager of the company's Sugar Creek, Missouri, refinery, as manager of the Neodesha, Kansas, refinery, effective July 1. Johnsen succeeds **Harry G. Schnetzler,** who is retiring.

C. O. Peyton

▸ **Paul D. Williams** has been re-elected secretary-treasurer of the Western Petroleum Refiners Association. **Miss Virginia W. Campbell** was re-elected assistant treasurer, and **Fayette B. Dow,** general counsel.

▸ **Charles O. Peyton** has been named to succeed **Donald O. Swan** as general manager of Esso Standard Oil Company's petroleum specialties department. Swan has become a vice president of Esso Export Corporation, and general manager of Esso Export's cargo sales department.

P. K. Kuhne

▸ **Paul K. Kuhne,** formerly director of refinery technology in the manufacturing department of Gulf Oil Corporation, has been placed in charge of the company's refinery technology laboratory at Philadelphia, Penn.

In Gulf's petrochemical department **W. C. King** has been named director of market research and economic analysis.

▸ **Dr. Henry J. Masson** has retired as assistant dean in charge of the graduate division of New York University's College of Engineering, ending an association of 41 years.

▸ Esso Research and Engineering Company has announced new assignments for three engineers. **James A. Plumstead Jr.** has been named engineering associate; **William W. Bray Jr.** is now head of the petrochemicals section in the firm's design engineering division, and **Leonard Hollander** has been appointed head of the design engineering division's equipment development section.

▸ **Dr. Hugo H. Peter** has been appointed technical representative for Standard Oil Company (Indiana) and its affiliate, Amoco Chemicals Corporation. He will headquarter in Paris, France.

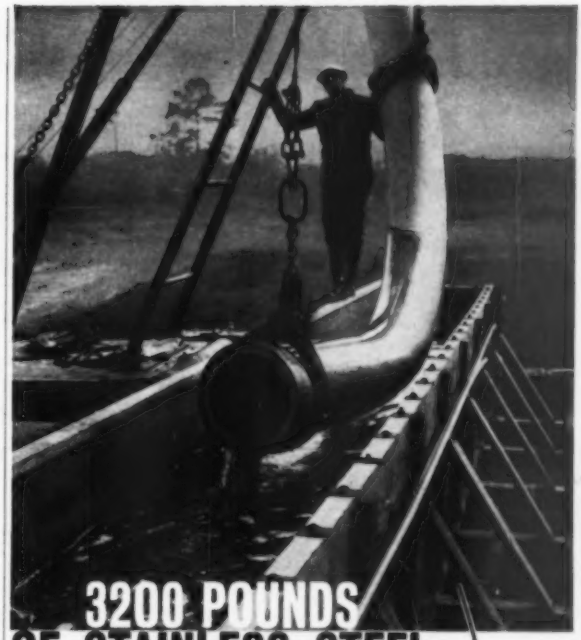
▸ **Chester L. May** of Dallas has been elected a director of Rio Grande Valley Gas Company in Brownsville, Texas, filling the post of the late O. P. Wilson. May in a former senior vice president and director of Lone Star Gas Company.

▸ **Dr. Adrien Leduc** has been appointed research associate of The M. W. Kellogg Company, a subsidiary of Pullman, Inc.

▸ **Everett W. Hubbard Jr.** has been named assistant to the vice president in charge of refining of Kerr-McGee Oil Industries, Inc. Hubbard was formerly senior mechanical engineer of Kerr-McGee's Cushing, Oklahoma, refinery.

▸ **Stanford B. Spracklen** has been appointed manager of the specialized engineering and applications unit of Beckman Instruments, Inc.'s new custom products department. Spracklen was formerly associate manager of engineering for the scientific and process instruments division.

▸ **Dr. Edward G. Baker** has been named a research associate in the chemicals research division of Esso Research and Engineering Company.



3200 POUNDS OF STAINLESS STEEL

CLEAN AS CLEAN CAN BE

The 3200 pound, 16 foot stainless steel pipe section shown above is an example of the piping to be used in the nation's largest atomic power plant. The pipe was fabricated in Houston by Southwest Fabricating and Welding Company. Before being shipped, every inch of each pipe section was thoroughly inspected to be sure that it was completely free of all dirt, mill scale, oxides, metal elements, and similar deposits. There could be no guesswork. *The pipe had to be hospital clean.* To guarantee that their piping was as clean as clean could be, Southwest called in the Nowery J. Smith Co.

The Smith corrosion prevention specialists have cleaned and passivated 1190 feet of the steel pipe to date. Pipe ranging to 22 inches in diameter, with wall thicknesses to 1.220 inches, was polish-blasted and then passivated to ASTM specifications to preserve cleanness.

If corrosion is a factor in the work-life of your equipment consult with the Nowery J. Smith Company during the design phase of your project. Think Nowery J. Smith Co. for Hot-Dip Galvanizing • Metallizing • Chemical Cleaning • Sand/Shot Blasting • Painting/Coatings • Plastics • Plastic Applications • Vessel Linings

LARGEST HOT-DIP GALVANIZERS IN THE SOUTHWEST

NOWERY J. SMITH CO.

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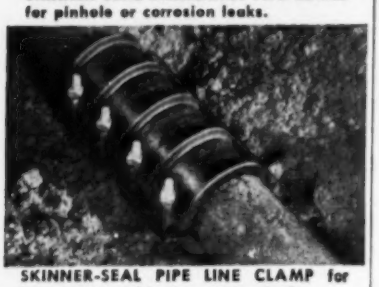
HOUSTON 8, TEXAS • UNderwood 9-1425

One of the Smith Industries —

PIPE LEAK REPAIR
— QUICK, FINAL!
ANY PRESSURE—ANY TEMPERATURE

SKINNER-SEAL EMERGENCY PIPE CLAMP
for pinhole or corrosion leaks.



SKINNER-SEAL PIPE LINE CLAMP for
long splits and bad corrosion leaks.

In stock—all supply stores

M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

for leakproof, pressure-tight connections

use TiteSeal®

SEALING COMPOUNDS

Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion, joint seizure.

7 BASIC BLENDS

LIQUID WRENCH®
The super-penetrating rust solvent

LOOSENS
rusted bolts, nuts, screws, 'frozen' parts

Liquid Wrench works *fast*... yet is absolutely safe for all metals and alloys.

2171

At Industrial, Automotive, Hardware, Plumbing Jobbers

RADIATOR SPECIALTY CO.
Charlotte, North Carolina

SOLDER SEAL

New Literature

Loading Equipment

Loading assemblies and loading valves are outlined in a booklet, "How to Select Your OPW Loading Assembly," offered by *OPW Corporation*. Diagrams illustrate how the valves discussed operate.

Circle number (50) on reply card.

Instrument Guide

Applications and advantages of instrumental analysis are presented in a comprehensive, 20-page brochure titled "Selecting Instruments to Solve Your Analytical Problems," issued by the instrument division of *Perkins-Elmer Corporation*. Reasons for the use of infrared and ultraviolet spectrophotometers and benefits obtained are included.

Circle number (51) on reply card.

Drum Cleaner

A completely automatic drum cleaner, capable of cleaning 1500 55-gal drums per 8-hr shift, is described in a folder issued by *Drumatic Corporation*. The Drumatic, which cleans drums to bare metal both inside and outside, enables one attendant to clean as many drums as a dozen men could do with ordinary methods.

Circle number (52) on reply card.

Brochure Released

Purifiers, scrubbers, mist extractors and separators for the natural gas and petroleum industry are the subject of an illustrated booklet released by *The V. D. Anderson Company*, division of *International Basic Economy Corporation*.

Circle number (53) on reply card.

Data Processing

A booklet on "New Concepts in Practical Automation and Electronic Computers" has been issued by *Royal McBee Corporation*. The booklet features the automatic Keysort system, which utilizes original records instead of tape or specially punched unit cards. Information on other Royal McBee equipment is included.

Circle number (54) on reply card.

Instruments Cataloged

Catalog 84, issued by *Burrell Corporation*, is a 52-page illustrated presentation on "Instruments for Gas and Vapor Chromatography." Kromo-Tog equipment and accessories, Fracton models, connectors and column packings are included in the comprehensive catalog.

Circle number (55) on reply card.

Resistant Condulets

Electrical equipment designed for use under many different conditions causing corrosion is featured in a publication of *Crouse-Hinds Company*. Corrosion-resistant properties of a variety of metals and finishes used in Crouse-Hinds Condulets are described.

Circle number (56) on reply card.

Fans Itemized

A complete line of induced draft fans is described in a 16-page bulletin, showing advantages and unique features, issued by *Lehigh Fan & Blower Division, Fuller Company*. Fully-dimensioned drawings and charts of ratings and specifications are included.

Circle number (57) on reply card.

Heat Transfer Items

Major items of heat transfer products manufactured by the *Brown Fintube Company* are listed and briefly described in a recent bulletin. Products included are hairpin heat exchangers, fired indirect heaters, tank heaters, process heaters and coolers, packaged boilers and custom built equipment. Also, the Brown Fintube, used in all Brown equipment, is described.

Circle number (58) on reply card.

"Cold" Fuel Blender

Onstream blending as provided by a 2-component blender, Model TCFR, is discussed in a bulletin from *B-I-F Industries, Inc.* Special emphasis is placed on direct batch blending of "Cold No. 5" fuel which may be used in commercial burners without preheating.

Circle number (59) on reply card.

Insulation Economy

Cost of installing lines and vessels carrying high temperature gases under pressure can be cut by a technique outlined in a pamphlet published by *Baldwin-Hill Company's Insidline Division*. According to the illustrated booklet, use of Insidline, patented internal insulation technique, reduces the temperature to which the steel shell is subjected, allowing use of inexpensive carbon steel piping for carrying gases up to 2000 F.

Circle number (60) on reply card.

Computer Introduced

Specifications and illustrations of the Datatron 220, hailed as the first computer to offer computational and data processing capacities of giant machines at half the cost, are given in a pamphlet released by *Electro Data Division, Burroughs Corporation*.

Circle number (61) on reply card.

Ethylene Amine Book

The Dow Chemical Company has announced the release of a 65-page publication on ethylene amines, designed for research chemists and technical personnel. Comprehensive coverage of ethylene amine chemistry, including properties, reactions, uses, first aid techniques, handling and storage, property graphs plus a bibliography, are included in the book, "Ethylene Amines."

Circle number (62) on reply card.

Tube Specifications

A new product reference catalog on Trufin, the integral finned tube originated by *Wolverine Tube*, division of *Calumet & Hecla, Inc.*, has been released, and lists all sizes, alloys, heat transfer data, application data, etc. for all types of integrally finned tube available for heat transfer applications.

Circle number (63) on reply card.

Motoreducer Bulletin

Bulletin 3100, a comprehensive 28-page report describing the complete line of Falk All-Motor and Integral Motoreducers, has been revised to incorporate recent changes in unit sizes and rerated NEMA standards. *Issued by The Falk Corporation.*

Circle number (64) on reply card.

New name, same fame for pipeline protection

Though we've changed the name from Barrett Protective Coatings to Allied Chemical, you'll still receive the same famous protection in Pipeline Coatings which have been proved and improved for three generations. Write for full information.

Pipeline Primers • Pipeline Enamels
Auxiliary Protective Service Materials
Last Word in Corrosion Protection

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INTERNATIONAL PETROLEUM EXPOSITION

TULSA U-S-A-
MAY 14-23
1959

for the latest developments in

PIPELINE CONSTRUCTION EQUIPMENT

be sure to visit the m.j. Crose *exhibit*

The Crose welcome mat is out to all petroleum industry men attending the International Petroleum Exposition from nations around the world. At the huge Crose exhibit, we will look forward to showing you the newest, most complete line of equipment now serving the pipeline construction industry on a world-wide basis.

M. J. CROSE MANUFACTURING COMPANY, INC.
Main Offices and Plant: Tulsa, Oklahoma
In Canada: Crose-Curran Ltd., Edmonton, Alberta

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

DURIRON

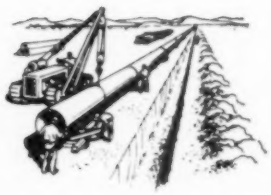
ANODE DATA SHEET

Number 5
Ground Bed

Basic engineering information about **DURIRON** *impressed current anodes for cathodic protection.*

Protection of a 30" Steel Water Line

Duriron Anodes Installed Without Backfill



THE PROBLEM: An isolated section of 11,000 feet of 30" steel water line needed cathodic protection. Tests showed the current requirements to be about 40 amperes, but it was planned to replace a section of the adjacent wood-stave line with steel, so extra capacity was desired. Only one site, about 4000 feet from one end of the section, had a power supply available. The ground at this location was a peat bog, with a resistivity of 4000 ohm-centimeters. The water table stood within six inches of the surface, making it impossible to get a dry, clean hole for the installation of anodes.

THE INSTALLATION: Thirty-two Duriron Type D anodes (2" x 60") were used, without backfill (Fig. 1). They were installed by digging through the dry surface soil for about one foot, and then pushing the anodes down until the tops were three feet below the surface (Fig. 2). The calculated resistance for the thirty-two anode group, at twenty foot spacing in two rows, was one ohm, based on previous experience with similar installations. Had it been possible to install anodes in conventional backfill columns, the requirements could have been met with twenty-two anodes. Under the circumstances, the use of bare anodes effected a considerable saving.

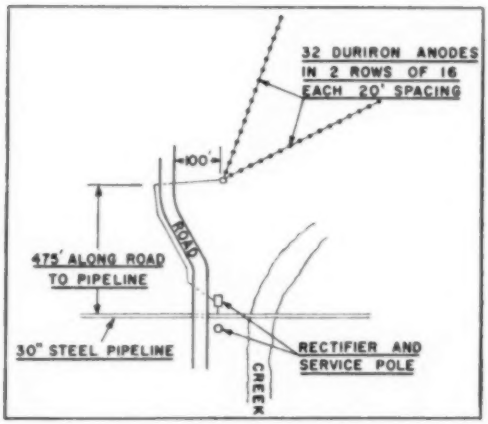


Fig. 1—Illustration of anode spacing

THE PERFORMANCE TO DATE: The anode bed is discharging 60 amperes at a terminal voltage of 59 volts. The entire line section is under protection, the minimum potential being 1.18 volts (referred to a copper-copper sulfate electrode placed over the line). This affords ample margin to handle anticipated additions to the line. It should be noted that the calculated anode resistance $R = .005\rho$ is quite close to the actual resistance of $R = .00491\rho$.

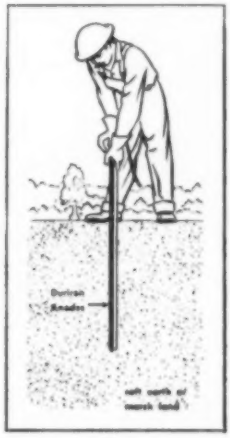


Fig. 2—Method of installing anodes

THE DURIRON COMPANY, INC.
Dayton 1, Ohio

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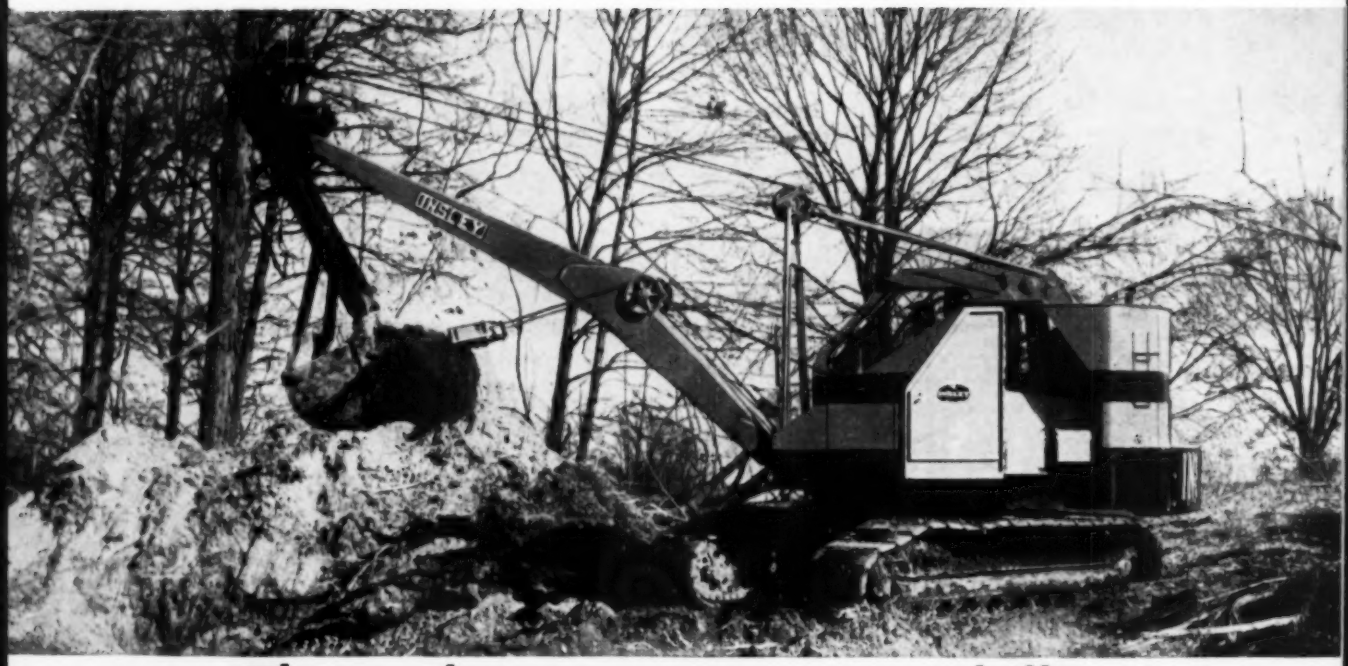

Through swamps... over hills pipeline work moves faster with the all-new

INSLEY M

Take the roughest terrain. Then put the new Insley M on the job and watch how pipeline trenching moves ahead—*faster!* Dependability is one reason. The rugged components of the Insley M are designed to stand up under the severest operating conditions. "Power matching" is another. The engine is correctly matched to the machine's capacity—for *maximum* efficiency. And here's a host of other reasons why you'll hear more and more pipeline contractors talking about the Insley M.

International Petroleum Exposition

May 14-23, 1959, Tulsa, Oklahoma.
See Insley's exhibit—East end, Block 9.

- Heavy-duty ¾ cu. yd. excavator • 15-ton crawler crane 20-ton rubber mounted crane.
- Wide-vision cab.
- Dependable mechanical clutches.
- Large diameter turntable with internal bull gear.
- Anti-friction bearings, aluminum bronze bearings and involute shaft splining.
- Wide, deep design crawler carbody.
- Sealed crawler rollers and end tumblers (optional).
- 12-ft., 6-in. crawlers standard.

Heavy-Duty Hoe Attachment • Box-Type Jack Frame • Brake-Type Cab Lock • Optional: Two-Speed Travel • Independent Travel • Independent Boom Hoist • Digging Dogs

THERE'S AN INSLEY WORKING NEAR YOU

INSLEY MANUFACTURING CORPORATION

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Tested by time... Proved by performance

NICOLET PIPE LINE FELTS

Nicolet Pipe Line Felts have passed through the toughest of all tests — the proving-grounds of actual use. They have stood up under the most adverse of soil and stress conditions — over many hundreds of miles of pipe line installations.

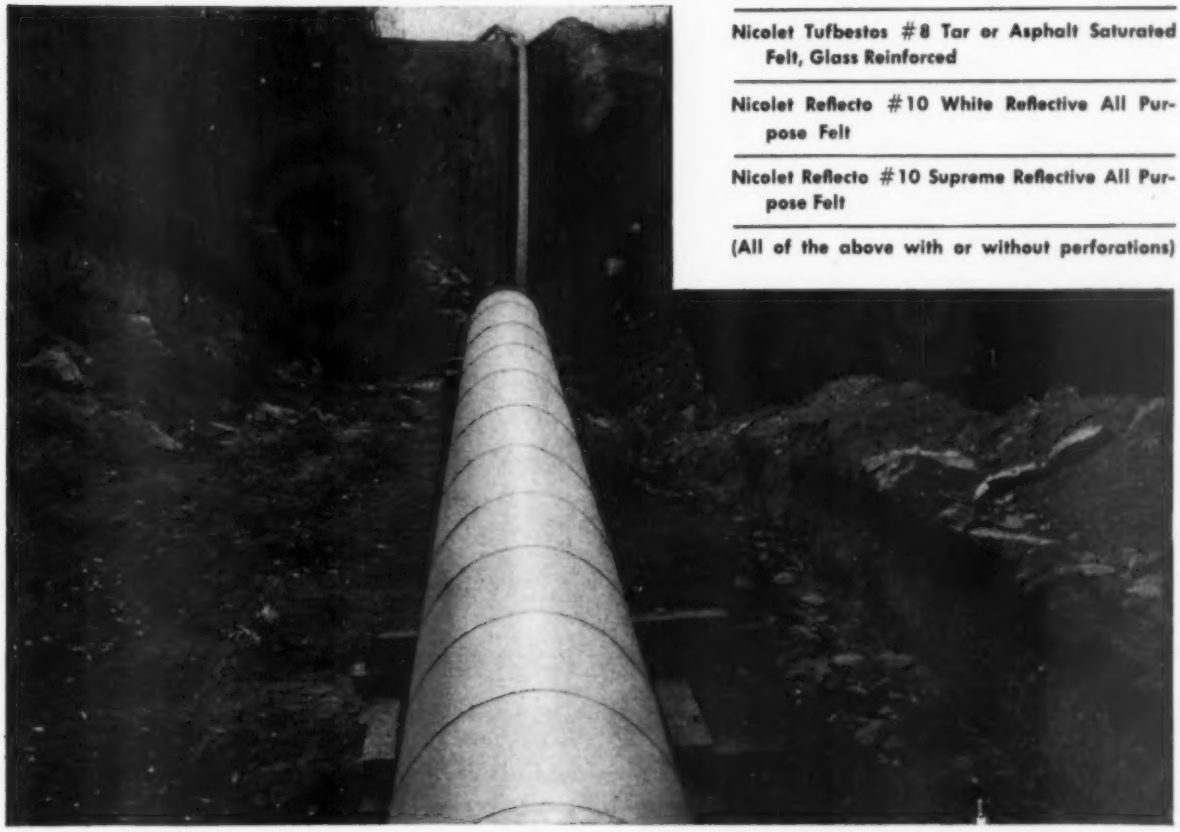
Because Nicolet makes the widest and finest range of Pipe Line Felts obtainable — 10 in all — you may be sure there is at least one perfect for the conditions you encounter.

When you specify Nicolet you are asking for the maximum in Pipe Line protection — and getting the safest, surest protection, hence the most economical, you can buy.

Pick the exact Nicolet Pipe Line Felts you need to meet your job specifications:

- **Nicolet Standard #15 Tar or Asphalt Saturated Felt, Plain**
- **Nicolet Standard #15 Tar or Asphalt Saturated Felt, Glass Reinforced**
- **Nicolet Tufbestos #8 Tar or Asphalt Saturated Felt, Plain**
- **Nicolet Tufbestos #8 Tar or Asphalt Saturated Felt, Glass Reinforced**
- **Nicolet Reflecto #10 White Reflective All Purpose Felt**
- **Nicolet Reflecto #10 Supreme Reflective All Purpose Felt**

(All of the above with or without perforations)



• **WRITE, WIRE OR PHONE TODAY FOR FULL INFORMATION about any or all the high quality Nicolet Pipe Line Felts.**

NICOLET INDUSTRIES, Inc.
FLORHAM PARK, NEW JERSEY
Norristown, Pa. • Hamilton, Ohio
DISTRIBUTED THROUGHOUT UNITED STATES.

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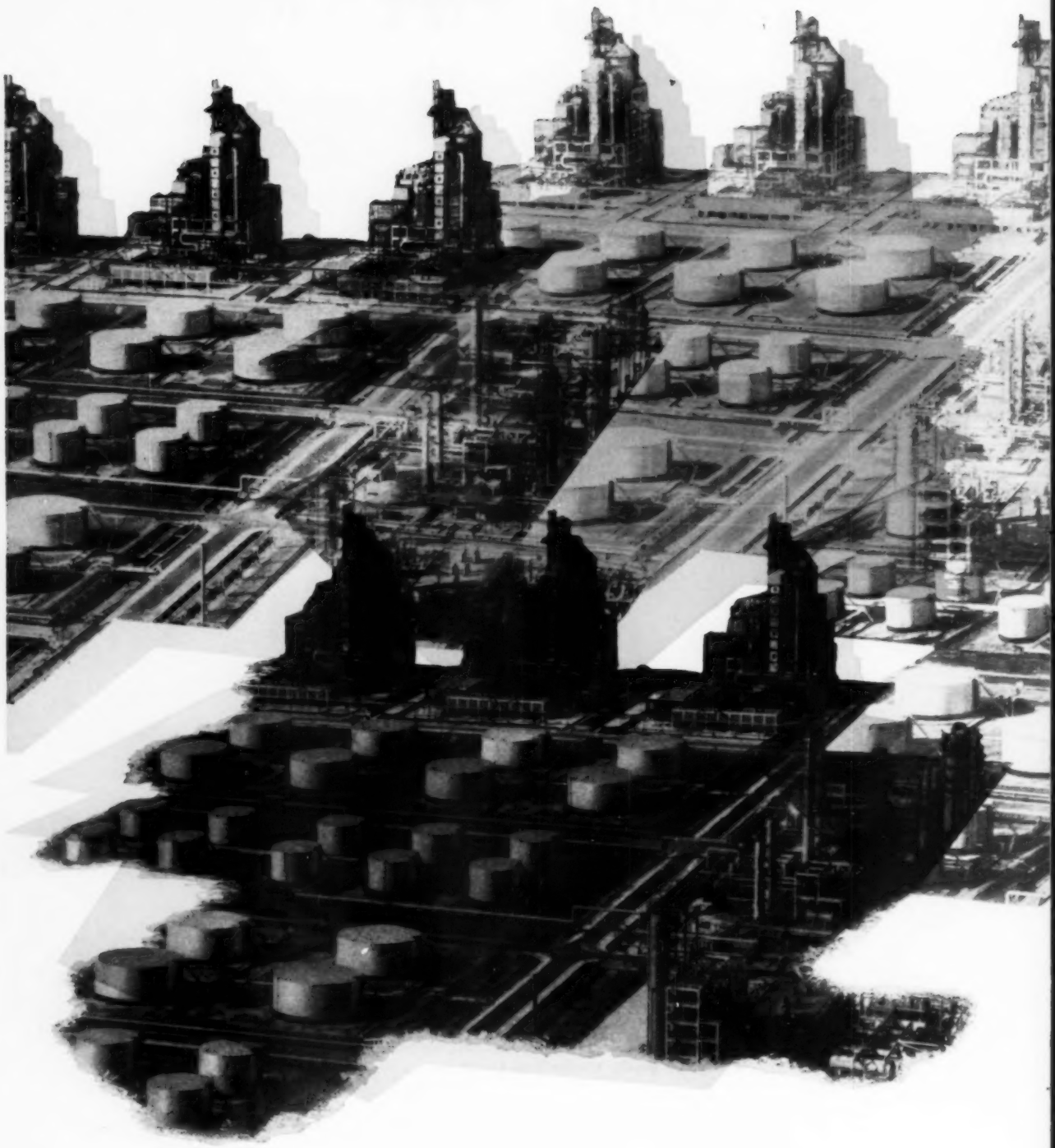
"Engineered



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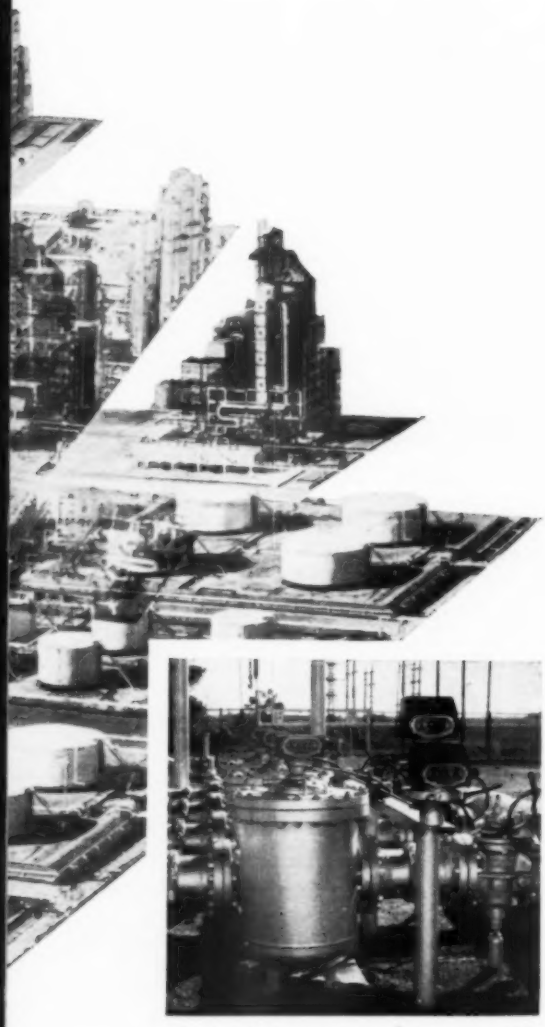
ADVERTISED PRODUCTS, SEE READER SERVICE CARD

meter systems"-

newest way to refinery expansion without buying real estate



With individual capacities ranging up to 3000 bph, these four A. O. Smith B-200 meters receive crude from a 16-inch line. Meters are connected by combinator units that register total throughput on counter-shifter ticket printer (foreground).

The road to expansion of refining facilities is frequently strewn with barriers — local zoning restrictions, expensive real estate or lack of available adjoining land.

To avert these drawbacks, more and more major pipeliners and refiners are turning to A. O. Smith engineered meter installations. Large volume A. O. Smith meters release measurement tankage for storage purposes . . . provide faster, less complicated throughput . . . reduce overall capital investment . . . slash tank filling and breathing losses.

Equally important, A. O. Smith engineered meter systems provide exceptionally accurate measurement of all transactions.

Before you plan tank-farm expansion you'll be money ahead to consult A. O. Smith. There are meters and accessories for every receiving line — crude, LPG or natural gasoline . . . models for a wide range of operating pressures. And, A. O. Smith meters are equally accurate in measuring finished petroleum products . . . offer similar space saving advantages. Contact your man from A. O. Smith today or write direct:

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NOW! POLYKEN CAN COST YOU 26% LESS

...and you get a tougher tape coating than ever!

1959 prices are down...yet Polyken #900 has a protective backing that's 25% heavier!

If your plant has a corrosion problem, odds are you need Polyken protective tape coatings.

More effective than paint . . . and more economical. Because there's no need to scrape down and repaint.

Even *more* economical, now! Due to greater manufacturing efficiency, Polyken quality is *up*, and 1959 prices are *down* as much as 26%. With Polyken, you get more for your money than ever before.

Polyken tape coating. Proved over the years as a top corrosion fighter in plants throughout the country. Why not use it in *your* plant?

CHECK YOUR COST ADVANTAGES AT THESE NEW LOW POLYKEN PRICES

ACCESSORY ROLL—1½ inch I.D. Core—100, 200, 300 ft. length—Price Per Square, Dollars

Quantity, Squares	Less than 102	102 to 500	501 to 1499	1500 to 2999	3000 to 5000	5001 to 25001	25002 and Over
No. 900 Black, 14 mils. No. 910 Gray, 12 mils. No. 940 Black, 12 mils. No. 940 Gray, 12 mils.	13.86	12.20	11.02	9.76	8.54	8.04	7.62
No. 920 Black, 20 mils.	19.30	17.22	15.56	13.78	12.06	11.38	10.76

PIPELINE ROLL—3 inch I.D. Core—400, 600, 800 ft. length—Price Per Square, Dollars

Quantity, Squares	Less than 102	102 to 500	501 to 1499	1500 to 2999	3000 to 5000	5001 to 25001	25002 and Over
No. 900 Black, 14 mils.	13.66	12.20	11.02	9.76	7.90	7.44	7.04
No. 920 Black, 20 mils.	19.30	17.22	15.56	13.78	11.16	10.52	9.95

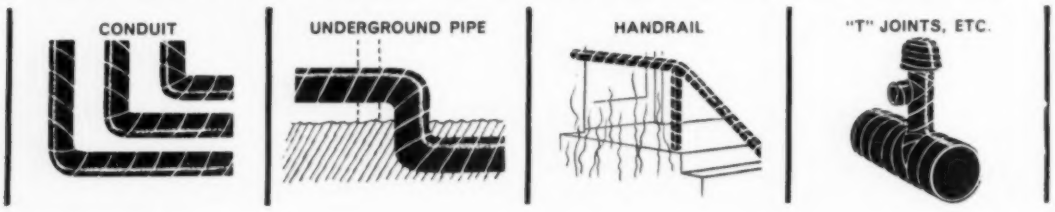
Polyken®

Experienced in modern PROTECTIVE COATINGS

THE KENDALL COMPANY

Polyken Sales Division

CHECK THESE DANGER POINTS IN YOUR PLANT *(and protect 'em with Polyken)*



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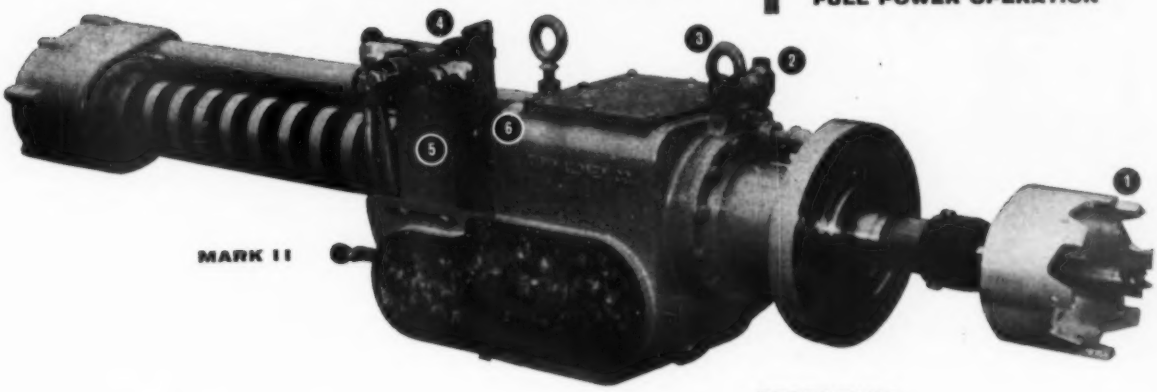
Completely NEW High-Pressure Pipe Tapping Machines

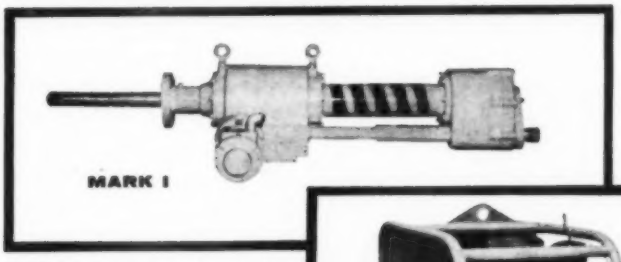
Maloney

MARK I
1 to 6 inch
air or hand crank

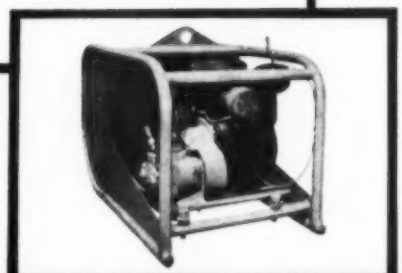
MARK II
4 to 16 inch
air or hydraulic
FULL POWER OPERATION



Over two years of intensive research and field testing have produced these all new high-pressure Tapping Machines. Conservatively rated at 1440 psi at 100° or 700 psi at 700°, the Maloney MARK I and MARK II incorporate every desired feature for rapid, safe, and accurate hot tapping, with complete power operation. Engineered and manufactured by the F. H. Maloney Company, completely within our own manufacturing facilities.



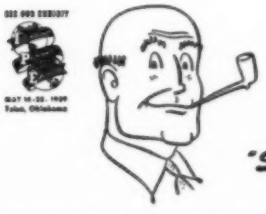
Based on the same design as the MARK II, the MARK I covers the range of high pressure taps from 1 inch to 6 inch. Available with air motor or hand crank operation, the MARK I is rated at the same operating pressures and temperatures as the MARK II. Twist drill cutters are available to 3 inch, shell type cutters to 6 inch. (MARK I Air Requirements 90 psi, @ 105 cfm.)



Companion Hydraulic Power Unit powered with 9 hp gasoline engine, completely self-contained. Provides ample power and positive control of cutter torque with calibrated, infinitely variable, flow control. Available as an accessory with the MARK II. (MARK II Air Requirements — 90 psi, @ 105 cfm.)

FEATURING

1. Revolutionary shell cutters provide cleaner cutting with less torque. Replaceable teeth, shell, and backplate for field maintenance.
2. Integral bleed-off valve.
3. Center of gravity well forward, near the cutting end of the machine, for easier handling. Vertical and horizontal operation with built-in lifting rings and bail.
4. Air or Hydraulic power (MARK II only), with ample reserve power. Completely reversible—makes the *full range* of cuts without alteration.
5. All operating controls grouped for simple operation.
6. Boring bar travel counter measures travel in .01 inch increments. No guessing where the cutter is.
7. Simplified design eliminates unnecessary maintenance. Designed to be operated and maintained by *your* operating personnel.



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F. H. Maloney COMPANY

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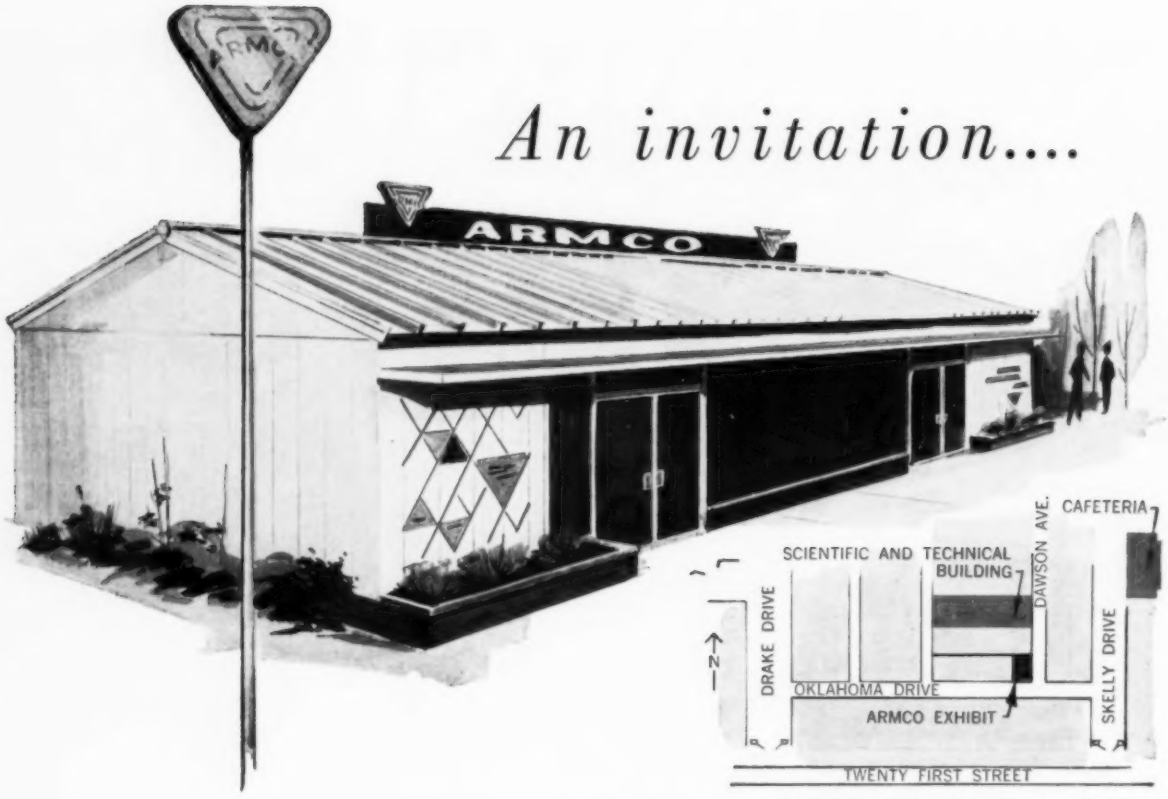
An invitation....



Follow this map to the Armco exhibit

Armco Drainage & Metal Products, Inc. cordially invites you to visit our exhibit at the International Petroleum Exposition.

May 15 through 24
N. W. Corner of Oklahoma Drive and Dawson Avenue
Exposition Grounds, Tulsa, Oklahoma

For your convenience, Armco products in this exhibit will be grouped into four classifications:

1. Production
2. Refining
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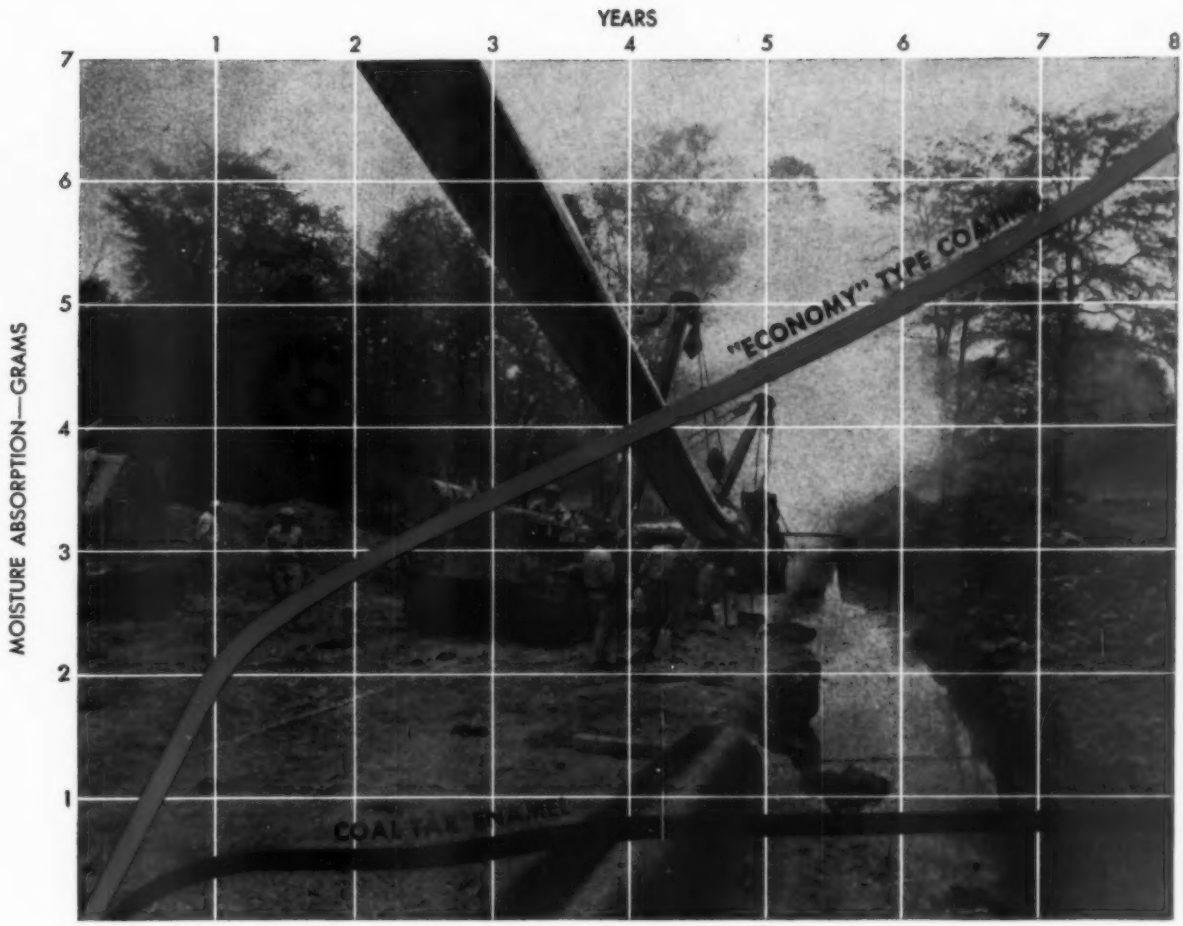

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THE chart above, prepared by an independent pipeline engineer*, shows why an overwhelming majority of pipeline owners and operators select *coal tar enamels* to protect their underground investment. No other coating material can *begin* to match the ability of coal tar enamel to resist moisture absorption.

Field tests show that an "economy type" coating exhibits a constant moisture absorption increase. The continuously increasing cost of cathodic protection soon eats up any first-cost savings in material. Peeling and deterioration eventually require expensive reconditioning.

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PITT CHEM maintains a full-time staff of field service men to work with your field men in the efficient application of pipeline enamels. *Write us about your protection requirements . . . today!*

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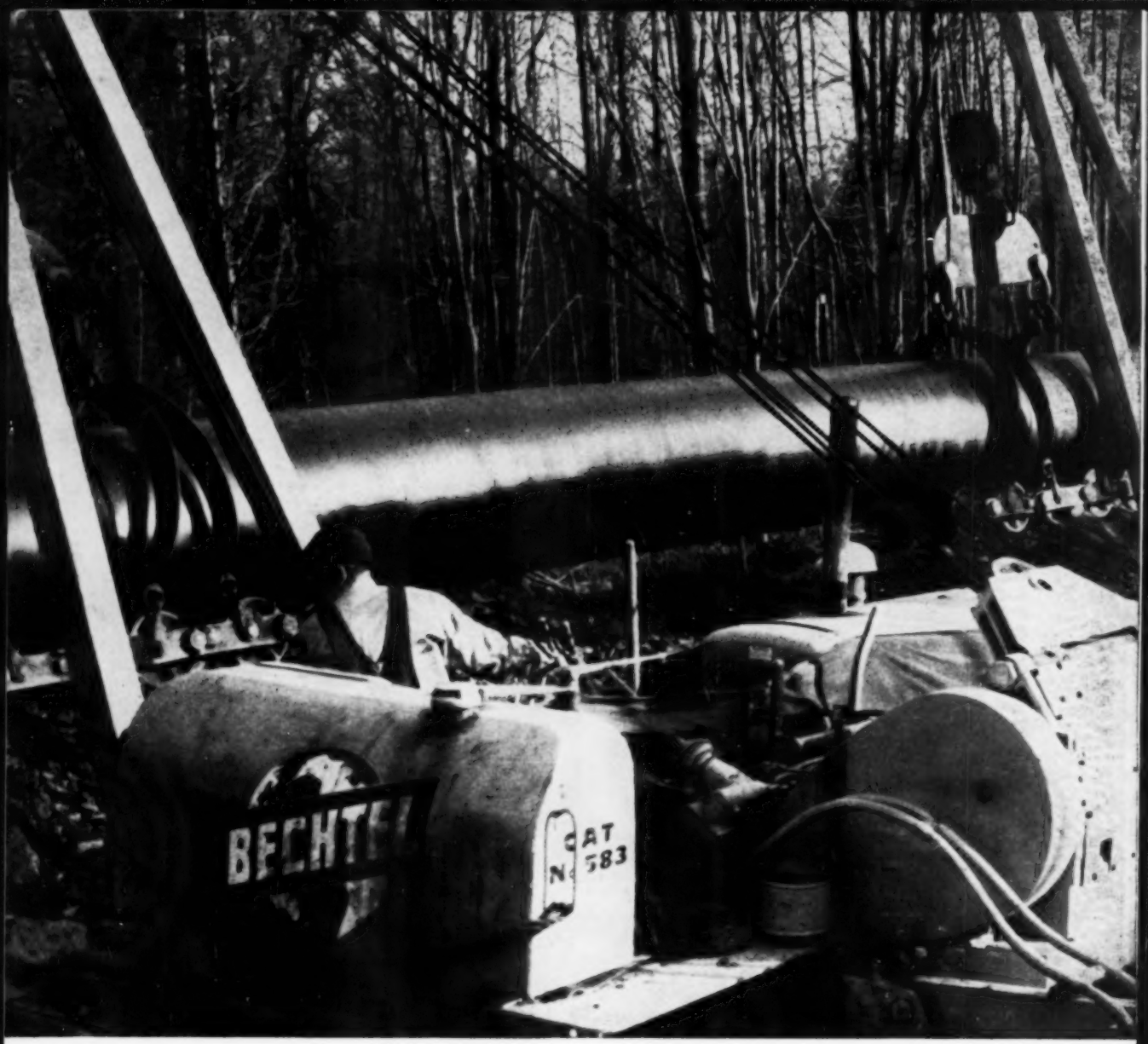

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HYDRAULICALLY EXPANDED ELECTRIC FUSION-WELD (submerged arc)	18 through 24 26 through 36 36 through 42	¼ to ½ incl. ¼ to ⅝ incl. ¼ to ¾ incl.	40-ft	API 5LX, Grades X42, X46, X52 & X56
ELECTRIC RESISTANCE-WELD	5 (nom) to 16	API	to 60-ft	API 5L, Grades A & B API 5LX, Grades X42 & X46
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COMPRESSOR STATION PIPE in diameters, thicknesses, and lengths as required.				

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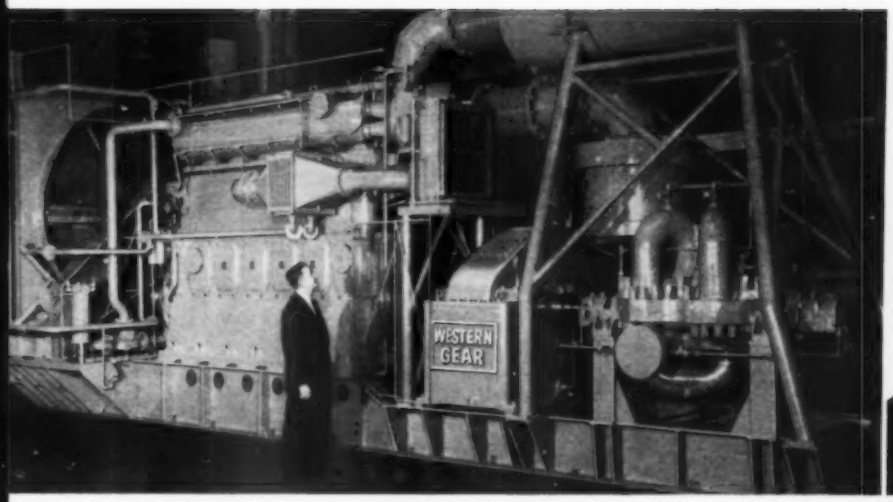

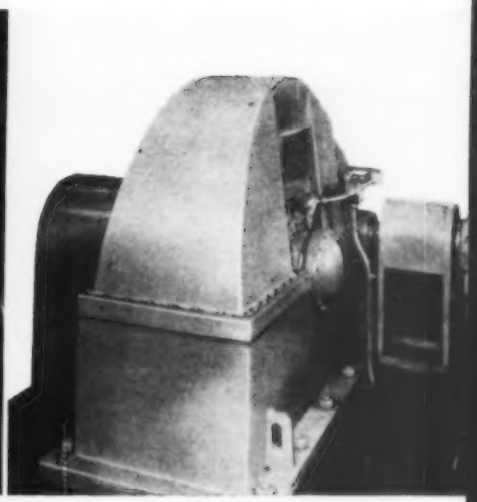

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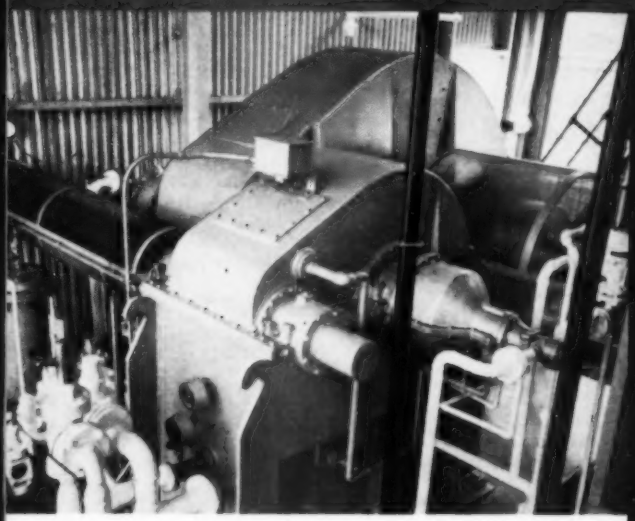

Western Gear engineers designed to order this two-stage high speed gear drive to step up the 5000 HP natural gas-operated 16 cylinder Cooper-Bessemer engine to power a centrifugal compressor at 6,055 RPM.

From Kentucky to Kuwait, Western Gear pipeline drives are pushing record volumes of crude oil, refined oil and natural gas.

Upper left illustrates one of four portable pumping units built by Enterprise Engine and Machinery Company to pump oil for American Independent Oil Company in Kuwait, Arabia. The Western Gear high speed drive boosts a 600 RPM input to 3550 RPM output at 4 points along the 35 mile bleak desert pipeline route.

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PIPELINE INSPECTION

45

TIMES FASTER BY HELICOPTER THAN BY FOOT

Pipeliners have discovered the Bell helicopter. You'll see the Bell saving them money wherever you look. Its ability to cut patrolling costs (as pointed out above) is remarkable enough . . but this is only a fraction of the story. For a glimpse at the Bell's amazing efficiency on your payroll — both in pipe stringing and maintenance — take a minute to run down the adjoining list of questions. We call it the BELL PENCIL TEST. You'll call it an eye-opener for pipeline contractors and operators.

YES	NO	
☐	☐	We have pipeline stations that require over 300 miles of ground travel.
☐	☐	Our construction schedules must be met, regardless of weather.
☐	☐	We've been using tracked vehicles to get equipment into some locations.
☐	☐	We need a fast communication and coordination link between field units.
☐	☐	We could sign up 1000 to 5000 new industrial customers next year if construction of new distribution facilities could be speeded up.

Now, tear out this page and mail it — with your name, title, company and address — to: Department 35E, Bell Helicopter Corporation, Fort Worth, Texas. We'll send you additional information about the Bell in Pipeline Business.

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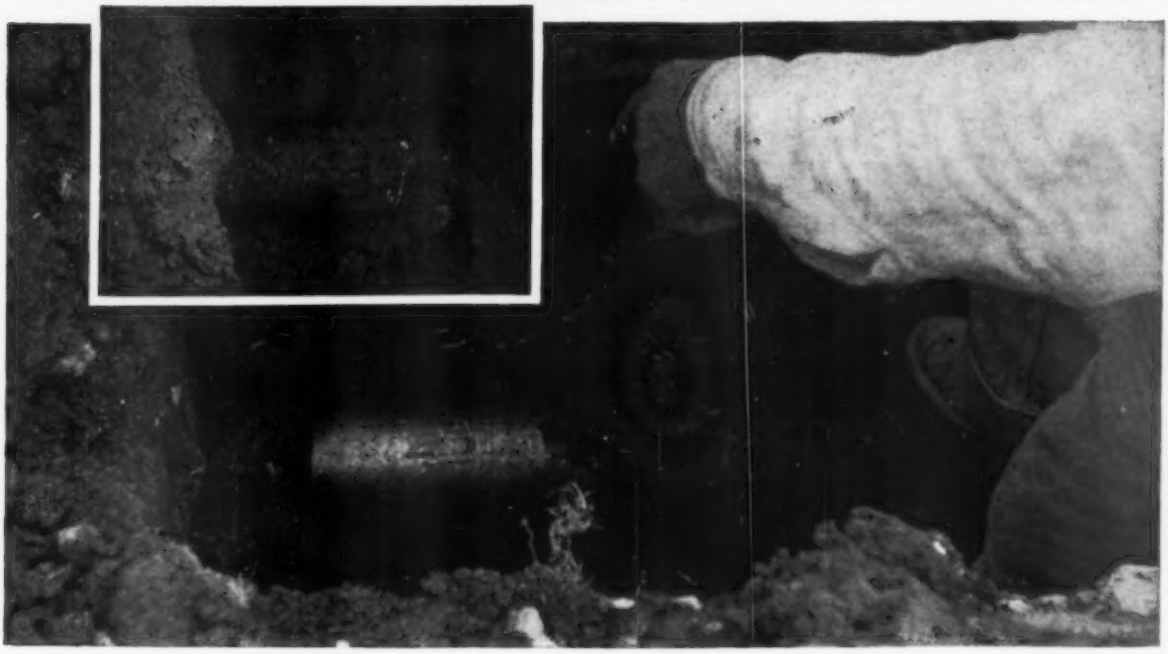

Year After Year...More Evidence Proving That TAPECOAT Adds Years of Service Life to Gas Lines Underground or Under Water

Right across the country, TAPECOAT installations prove that you get more for your money when you measure pipe protection with a calendar.

Since this cost-cutting coal tar coating in tape form was first introduced in 1941, it has demonstrated its ability to withstand severe conditions underground or under water. TAPECOATED lines dug up after 17 years of service show no signs of deterioration on the pipe.

Typical is the experience of a utility in a coastal area. For a thorough trial, this company applied TAPECOAT in areas where severe corrosive conditions were known to exist. The lines were dug up this year and, after years of service under severe conditions such as brackish waters and corrosive soil, the pipe showed no signs of corrosion, proving the quality of TAPECOAT protection.

In terms of preventive maintenance and replacement costs, performances like this emphasize the most important consideration in buying protection. Remember, TAPECOAT is a hot-applied coal tar coating in tape form—designed for lasting protection on pipe, pipe joints, service connections, mechanical couplings, fittings, insulated lines, tanks, tie rods, and other steel surfaces vulnerable to corrosion.

TAPECOAT comes in rolls of various widths and is available in asphalt. Where primer is desired, specify TC Primecoat, the compatible coal tar primer.

A TAPECOAT sales and service engineer is always available to help you on any corrosion problem. Write for complete details today!

The TAPECOAT *Company*

ORIGINATORS OF COAL TAR COATING IN TAPE FORM

1533 Lyons Street, Evanston, Illinois

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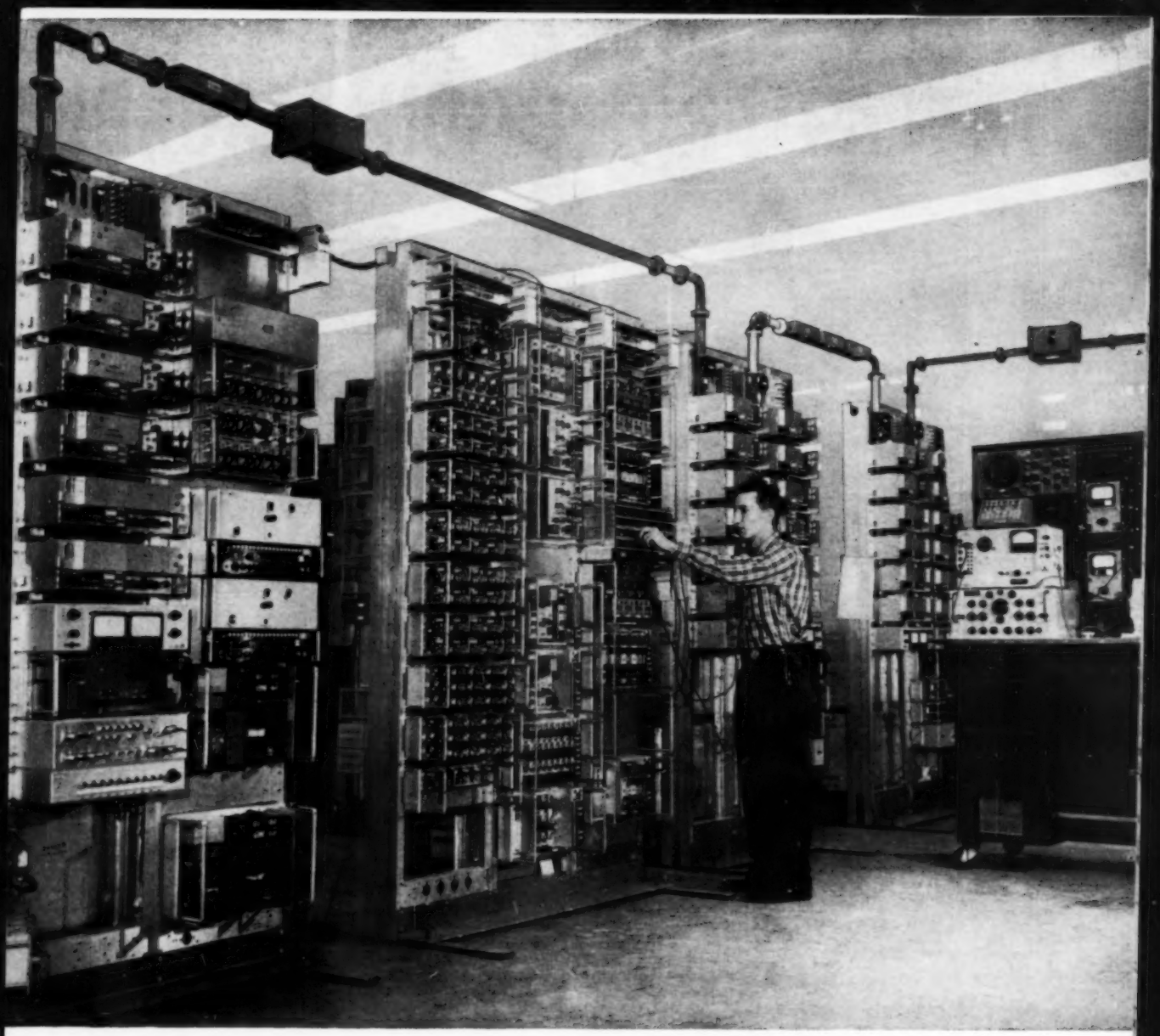

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Collins racks are assembled, wired, tested and shipped as a unit to each site ready for setting in place and going to work.

Your microwave dollar buys more service, more reliability, more flexibility and more value when you specify *Collins*. For complete information, write or call Microwave Sales Division, Collins Radio Company, 1930 Hi-Line Drive, Dallas 7, Texas.

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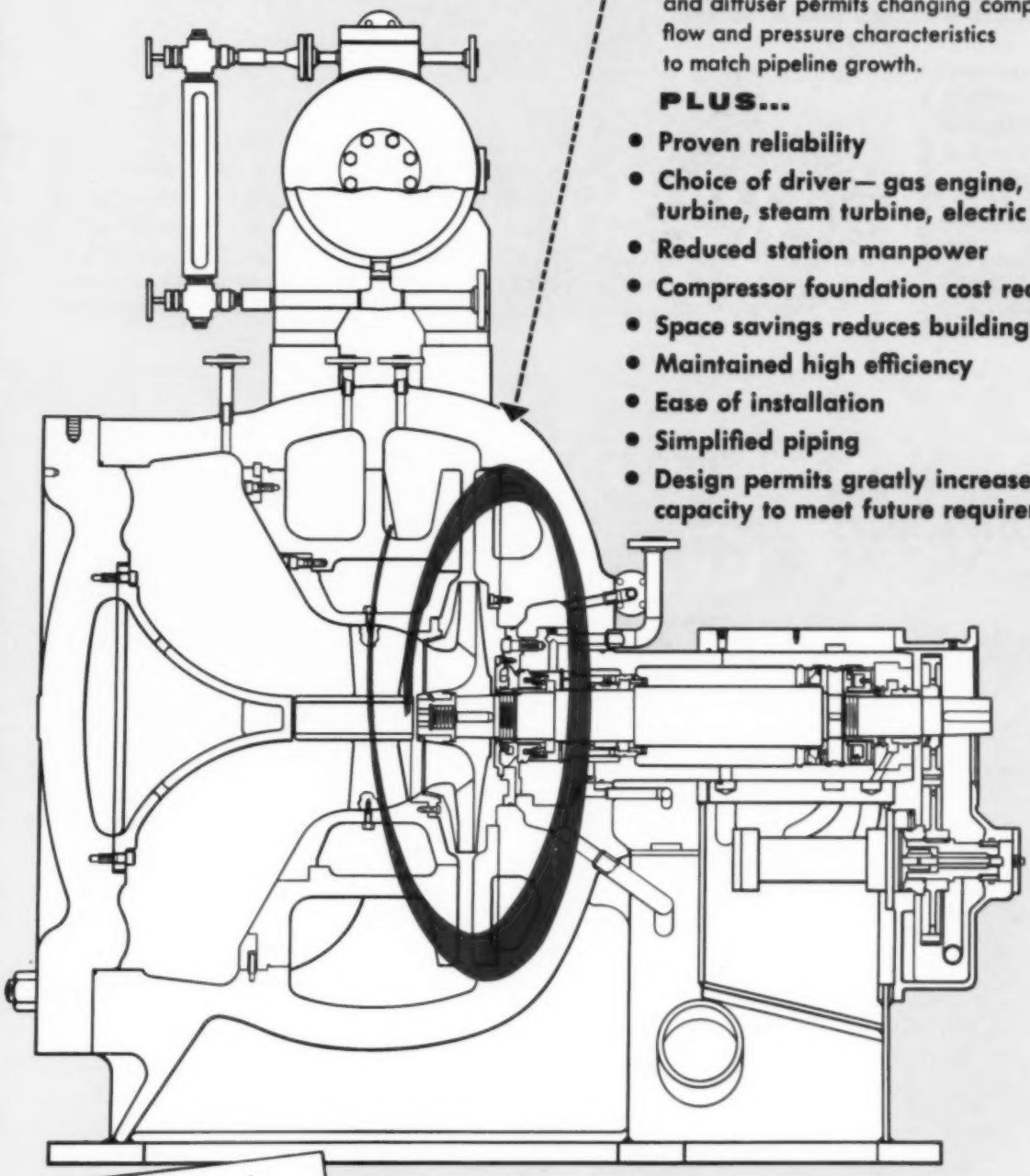

Readily interchangeable impeller and diffuser permits changing compressor flow and pressure characteristics to match pipeline growth.

PLUS...

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- **Choice of driver — gas engine, gas turbine, steam turbine, electric motor**
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- **Maintained high efficiency**
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- **Design permits greatly increased capacity to meet future requirements**

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Centralized Monitoring With Digital Telemetering

System of increased magnitude is handled on narrow frequency spectrum, conserving channel space

G. L. Maciula
Chief Engineer
Service Pipe Line Company

PROBLEMS inherent in moving large volumes of several different grades of crude oil over long distances through a complex pipeline system make it necessary that the operators know at all times the rates of flow, pressures, location of interfaces, and volumes in every section of the system. When this information is delivered to a central point by instrumentation rather than manual communication, we have centralized monitoring.

This is also the key to unattended operation of pumping stations because the means used to monitor are also used to control operations. Centralized monitoring implies both control and supervision of facilities at a remotely located point.

Control and Supervision

In the language of telemetry, there is a difference between a control operation and supervisory operations. This is illustrated in Fig. 1. An example of a control operation is shown at the top. Closing of contacts through a pushbutton at the central office results in the starting of a motor at a remote point. The end result is obtained by having the pushbutton energize a tone transmitter, which in turn energizes a receiver and actuates a relay contact to make the circuit at the remote point.

The lower part of Fig. 1 shows a supervisory indication. In this case, the closing by pressure of a contact at the remote point is indicated by a lighted bulb on a panel at the central monitoring location. The indication could be caused by any action at a remote point that can operate an electrical contactor. Significant in Fig. 1 is that in each case the operation was carried out over a communication circuit and not on a power circuit. The circuit may be wire line, radio or microwave. When the system extends to measuring variables, we have telemetering.

Control operations apply to starting and stopping of pumps, operating gate valves, changing speeds of engines, etc. Supervisory indications coming back to control points tell the condition of things and information such as line pressures, flow, tank levels, gravity, and machinery faults. Thus, control functions are commands that opera-

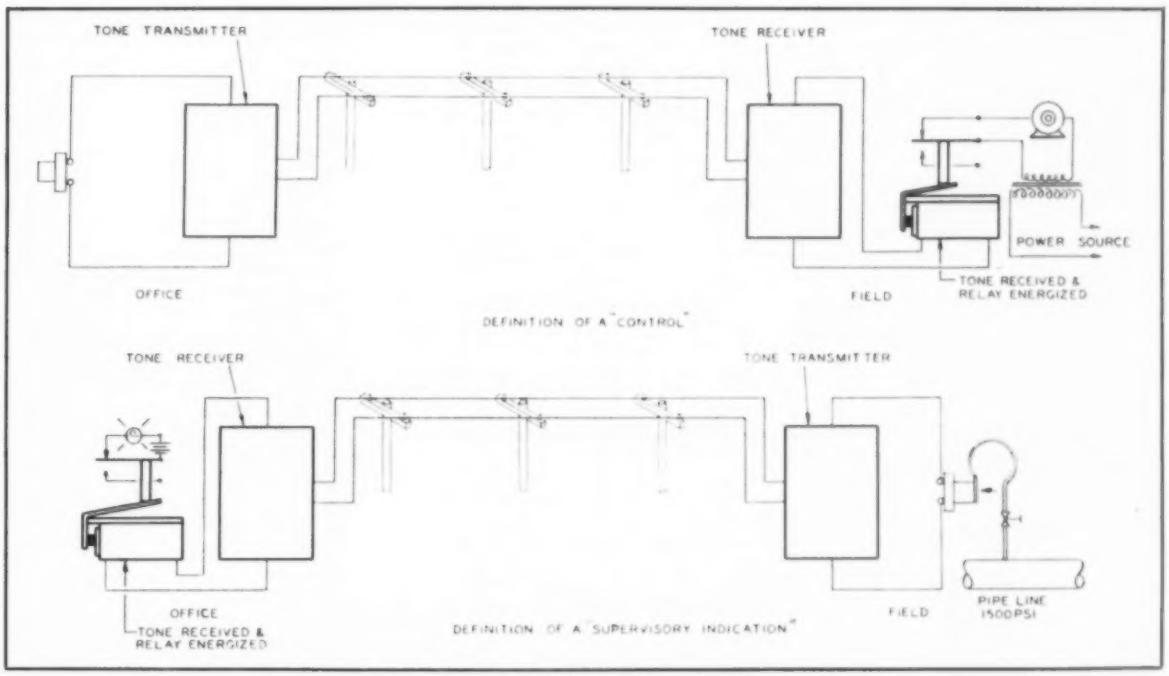
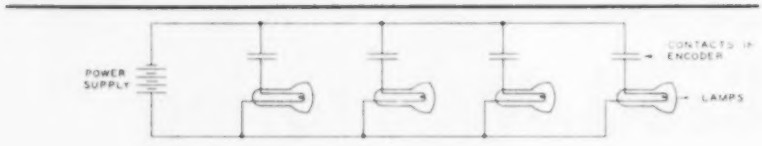


FIG. 1. Definition of control and supervisory indication.



DECIMAL NUMBER				
0	x	o	o	o
1	x	x	o	o
2	o	x	o	o
3	o	x	x	o
4	o	o	x	o
5	o	o	x	x
6	o	x	x	x
7	o	x	o	x
8	x	x	o	x
9	x	o	o	x
0	x	o	o	o

o = CONTACTS OPEN
x = CONTACTS CLOSED

FIG. 2. A different number system.

tions take place, while supervisory indications tell the results of these operations. Supervisory indications give information of the "yes or no," "on-off" or "how much" type. The "yes or no" or "on-off" type of indication tells the operator at the control point that a pump is running or is not running, that a gate is open or closed, that there is a machinery fault, or anything that can be indicated by a simple switch. The "how much" indications apply to such variables as flows, pressures, levels, etc., and involve a more complicated means of measurement.

Communication System

With a multitude of indications coming into a control center and a score of commands going out from this center, a communication circuit may be overburdened in short order if each function is assigned a separate impressed tone. Most monitoring systems available are based on ingenious designs for using a minimum number of tones in order to conserve communication requirements.

Since communication space, whether owned or leased, costs money, efficient use of such space becomes very important. The simplest and least expensive type of communication is the single telegraph channel with a frequency width of 15 cps. Next is a voice channel with a width of 3000 cps and, for purposes of comparison, a 90-channel, 1,000,000-cps microwave system and a TV channel of 5,000,000 cps. All can be used for centralized monitoring. Because communication costs are generally proportional to the width of the frequency spectrum, it is apparent that the telegraph and voice channel are most attractive economically.

Analogue

Our first attempts for centralized control of pipeline facilities were installed on 3000-cycle voice channels. A spectrum of 3000 cycles can be used conveniently to handle 15 distinct tones, sufficient to control a small pumping system. In such a system, tones or combinations of tones are assigned to distinct functions, i.e., station start and stop, machinery faults, position of suction and discharge gates, pressures, flows, etc.

These are not all "yes or no" type signals so a problem arose in regard to indicating with a single tone a variable such as pressure. This was done by making the length of time the tone was impressed on the circuit proportional or analogous to the variable.

Many clever adaptations of this principle have been used. Systems of this type have been classed by the trade as "analogue." Most telemetering applications today are of this type. While many of these give excellent performance, their popularity is based primarily on their priority in the field.

Digital

The trend today, at least in our case, is away from analogue toward digital systems. These offer an improvement in that a centralized monitoring system of greater magnitude can be handled on a very narrow frequency spectrum such as a telegraph channel. This is accomplished by using only one tone, which is either on or off. By serializing the on-or-off tone pulses into combinations as on-on-off or on-off-off-on-off, etc., a series of 20 or 30 on-or-off pulses can be arranged into codes that handle a great deal of information. Thus, supervisory indications of the "yes or no" and telemetering of the quantitative data are transmitted in the same manner on a narrow frequency band and enables us to conserve much communication space.

Centralized monitoring designed around "on-off" type pulses is not necessarily a digital system. The connotation digital derives from the manner in which the quantitative type information is transmitted. This requires a binary number system and is similar to the manner in which electronic computers handle data processing.

It is possible to characterize any number from zero to nine by using combinations of only four "on-off" signals in a series. Fig. 2 illustrates one pattern for doing this. We have here four lamps that can be either on or off. The tabulation shown indicates which combination of contacts will need to be open or closed for any single digit.

A decimal number thus can be displayed or interpreted by the sequence in which four contacts are either open or closed. Information pertaining to pressures, flows, and gravity normally requires at least three digits for which 12 contacts will be necessary. This is illustrated at the top of Fig. 3, which shows the pattern for the number 665. In this case, four of the contacts are assigned to each of the units, tens and hundredths values.

Pressure and flow often require four digits, but only the first three figures are significant and the fourth or units digit is assumed to be zero. This is permissible because primary measuring and recording instruments can seldom be read closer than to three places.

G. L. Maciula, *a native of Bartlesville, Oklahoma, was graduated from Oklahoma A & M College as a mechanical engineer. He has been with Service Pipe Line Company since 1946, as a division chief engineer stationed in Lubbock, Texas, and a senior engineer stationed in the Tulsa general headquarters. In 1952, Maciula was made assistant manager of the Oklahoma division at Shawnee. He was transferred to Galesburg as assistant manager of the former Illinois division in 1954. In 1956, when the Missouri and Illinois divisions were consolidated, he transferred to Raytown, Missouri, to supervise the former Missouri division. In May 1957, he was appointed chief engineer.*

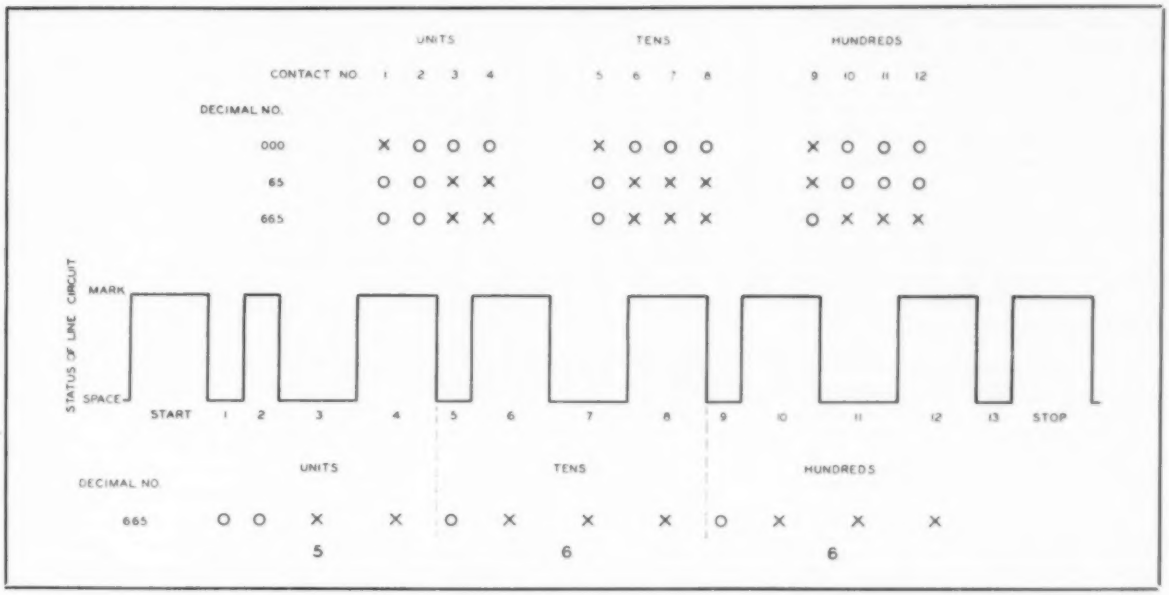


FIG. 3. Decimal number to cyclic binary decimal.

This policy gives practical accuracy, and results in considerable savings in transmitting and receiving equipment of the centralized monitoring system.

The "how much" type of information, which must be read as a decimal number, is sent as a series of long and short pulses, as indicated in the lower part of Fig. 3. Pulses are characterized by contacts either open or closed on an encoder plate, which is positioned by the measured variable.

Both the transmitting and receiving of centralized monitoring information is accomplished by systems of relays at each location. In order to conserve equipment the relays are interconnected so that long and short pulses representing either an open or closed contact have meaning, as shown in Fig. 3. Thus, the number 665 is shown in code form in the illustration as being made up of six marks or pulses and six pauses or spaces. In actual practice the coded information contains additional pulses by which the information is identified.

Diagram of Centralized Monitoring

Fig. 4 is a block diagram of a centralized monitoring system. The lower left side shows information received by the dispatcher or other operator from which he makes decisions. His manipulation of a pushbutton panel allows him to send out control commands through the information transmitter. These commands are carried by microwave or wire line to the information receiver at the remote point where the coded signal is converted into a local command acting on the pipeline facility.

The block diagram also shows where information of the "yes or no" and "how much" type is gathered into the information storage center from which it is transmitted to the centralized monitoring office. There this information is stored in the data storage center before being given to the dispatcher at intervals as recorded or indicated information. Of course, "how much" type information displayed is in decimal units and not binary code.

Pros and Cons of Digital System

We have mentioned that digital systems conserve communication channel space. Generally, this is important but the case for digitizing does not end there. It is natural that anyone considering a monitoring system will be interested in its accuracy, reliability, and means for recording information. In these factors the digital system is superior.

A well-designed analogue system is probably equal to a digital system insofar as accuracy of control commands and "yes or no" type supervisory indications are concerned. The difference is in handling the "how much" indications. Quite often electrical interference will degrade and cause error in the analogue signal, which is based on time. This is not true for the coded impulses of a digital system. When a disturbance affects the coded message, the transmitter is reset and repeats sending until the correct information is received.

Automatic Print-Out Machines

At the receiving end, the digital system makes possible the display of much information in a minimum of space. Indications of the "yes or no" type are shown by annunciator panels or lights as with any system, but information of the "how much" type is read on in-

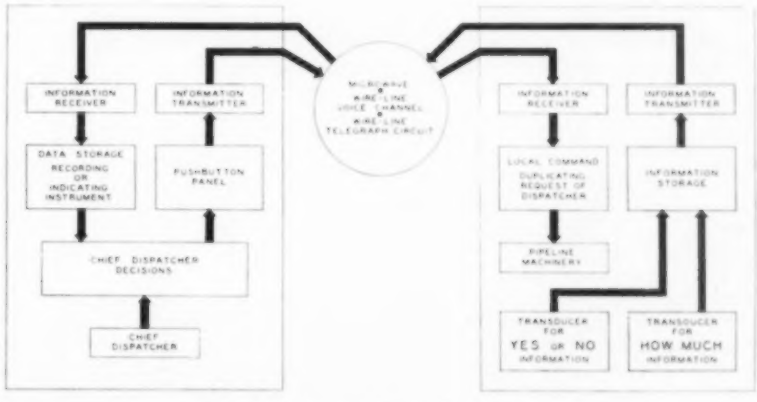


FIG. 4. Block diagram of centralized monitoring.

line type indicators or logged directly by automatic print-out machines.

To demonstrate the use of automatic print-out, Fig. 5 shows a log sheet of a typical section of line that has an originating station, three relay stations, and a terminating station. This shows the outgoing flow at the originating station and the incoming flow at the terminating station, the suction, pump case, and line discharge pressures at the three intermediate booster stations and the flow at one of these stations. Under normal conditions, this information is printed every hour. When an upset occurs in the system, the print-out begins immediately and continues every minute until normal conditions are re-established.

Fig. 5 shows that logging of data took place every minute. Repetition of this type is a feature of our logging equipment, which can be adjusted to print at intervals of 1 minute to 60 minutes. This illustration is taken from a test during which pressure changes and flow rates were being studied while intermediate booster stations were coming on the line.

System Time	Station	Flow Rate	Station	Suc. Press.	Case Press.	Line Press.	Station	Suc. Press.	Case Press.	Line Press.	Flow Rate	Station	Suc. Press.	Case Press.	Line Press.	Station	Flow Rate
4-13:44	0	1910	A	367	1050	940	B	706	680	700	2130	C	314	310	310	T	2140 -
4-13:45	0	1960	A	356	1040	940	B	706	680	700	2110	C	314	310	310	T	2160 -
4-13:46	0	2010	A	348	1030	940	B	706	680	700	2110	C	314	900	310	T	2140 -
4-13:47	0	2040	A	341	1020	940	B	706	680	700	2110	C	312	900	310	T	2150 -
4-13:48	0	2080	A	339	1020	940	B	706	680	700	2110	C	316	880	320	T	2160 -
4-13:49	0	2100	A	337	1020	940	B	706	680	700	2110	C	283	780	340	T	2130 -
4-13:50	0	2130	A	337	1020	940	B	693	680	690	2170	C	192	660	400	T	2340 -
4-13:51	0	2120	A	327	1000	940	B	658	650	660	2320	C	118	570	440	T	2610 -
4-13:52	0	2140	A	308	980	940	B	625	610	620	2430	C	70	520	450	T	2750 -
4-13:53	0	2170	A	292	960	930	B	600	590	600	2520	C	38	490	460	T	2820 -
4-13:54	0	2220	A	280	940	920	B	579	570	570	2550	C	37	510	440	T	2800 -
4-13:55	0	2260	A	268	930	910	B	568	560	560	2530	C	37	510	430	T	2740 -
4-13:56	0	2320	-A	260	920	900	B	560	550	560	2520	C	37	520	420	T	2670 -
4-13:57	0	2340	A	254	910	900	B	554	540	550	2510	C	37	520	410	T	2630 -
4-13:58	0	2380	A	250	910	890	B	551	540	550	2490	C	38	520	410	T	2610 -
4-13:59	0	2410	A	248	910	890	B	547	540	540	2490	C	38	520	400	T	2590 -
4-14:00	0	2430	A	246	910	890	B	545	530	540	2490	C	38	520	400	T	2570 -
4-14:01	0	2440	-A	245	910	890	B	544	530	540	2490	C	38	520	400	T	2560 -
4-14:02	0	2440	-A	245	900	890	B	542	530	540	2480	C	38	520	400	T	2550 -
4-14:02	0	2440	A	245	910	890	B	541	530	540	2480	C	38	530	400	T	2550 -

NOTE: Station B is being bypassed.

FIG. 5. Typical data log sheet.

Easier to Use

Other advantages can be cited for the digital system, such as the ease with which information received at one control point can be sent on to a master control center. Digital systems also contain the essential fundamentals for feeding a computer, and increase the possibility that someday we may use such devices for operating decisions.

Higher Cost

A couple of disadvantages of digital systems are the somewhat higher first cost of telemetering equipment, and the nuisance of having to double several primary instruments at the controlled station. Progress is being made to reduce the cost of equipment although we have found no difficulty in justifying it to date. Progress is also being made by instrument manufacturers to supply dual-purpose equipment that will give local control and security to our pumping stations and at the same time fit directly into a centralized monitoring system. ★ ★ ★

NOT A MISSILE LAUNCHING . . .

A Microwave Tower is Being Erected

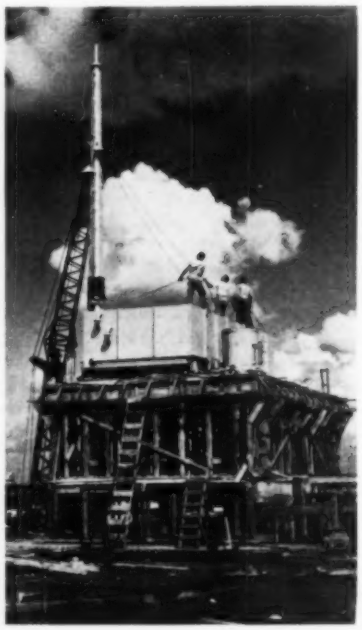
ALTHOUGH the accompanying photograph reminds of a missile or satellite launching, it depicts something quite different. This unusual looking equipment is nothing more than a microwave tower that has been erected atop Trunkline Gas Company's new central office building in Houston, Texas. But designing engineers sought to create a tower architecturally compatible with the modern office building now under construction, and at the same time one that would be structurally sound and highly resistant to the effects of air turbulence.

The tower is constructed of three sections of 6-in. line pipe covered with rolled ⅛-in. plates that completely enclose them. When fully equipped with dishes it will weigh approximately 6000 lb.

Thickness of the pipes was decreased upwardly to reduce unwanted weight at the top. At the base they form an equilateral triangle. The two rear pipe legs rise vertically and the forward pipe leg leans toward the apex of the rear legs. Spacer plates within the tower give maximum reinforcement. The three pipe legs serve as conduits for coaxial cables.

After fabrication the tower was coated with aluminum, sprayed on to a thickness of 10 to 12,000th of an inch, which should greatly reduce the frequency of maintenance, and at the same time provide weather-proofing and eye appeal.

The 49-ft tower will support a 10-ft diam microwave dish at the top and a 6-ft dish near the base, in addition to a VHF antenna. These dishes will be installed when the building has been completed.



With a special problem to solve as throughputs and pressures increased, Plantation Pipe Line found its answer in . . .

ELECTRO-HYDRAULIC CONTROLS

William H. Massey, Jr.
Research Section, Engineering Department
Plantation Pipe Line Company

FOR MORE THAN a decade Plantation Pipe Line Company's primary means of balancing hydraulic gradients, and caring for transient conditions along the system, has been with pneumatic controllers coupled with spring-opposed diaphragm valves. (See Fig. 1.)

Theoretically, the pipeline and associated pumps are designed to develop full capacity on gasoline without the use of throttling equipment. But, in reality, with intermediate delivery points and products in the line having different gravities and viscosities, the control valve is required to function much of the time. When line conditions require, the control system should:

1. Throttle as pump suction pressures approach a present low limit.
2. Throttle as station discharge pressures approach a preset high limit.
3. Throttle as flows approach a preset high limit (at originating stations only), or throttle as motor loads approach a preset high limit (at unattended stations only).

Although the pneumatic system has performed these control tasks satisfactorily, there have been maintenance problems introduced that are troublesome and costly in loss of throughput. Paramount among these problems is that of drying instrument air, particularly when ambient temperatures drop to the freezing zone.

It should be mentioned that excellent air-drying equipment is available, but, as a general rule, initial cost of the equipment is quite high, and recharging the elements imposes an additional task on maintenance personnel. It is not economical in a system like Plantation's, where prime movers and all auxiliary equipment are powered by electricity, to invest large sums of money for air-producing, air-filtering, and air-drying equipment when its only function is to position a single control valve.

As throughputs were increased and pressures more nearly approached the design limits of the system, more accurate pressure protective shutdown devices were installed. Along with this came the narrowing of the span between maximum pressure control points and maximum pressure protective shutdown points. All this imposed more serious demands on the control system, particularly when there were transient upsets within the control loop of the station itself. It was under these conditions that another problem of air appeared. With the inherent lag in any air system, it is difficult for a control valve, with a complete upset, to seek a new control position without some overshoot in stem travel. If this overshoot continues for several cycles under "tight line" operations, the results are pressure surges, which will mean the loss of one or all pumping units.

Critical Problem at Unattended Stations

It wasn't until Plantation built remotely controlled unattended pumping stations in 1953 that these and other air problems became critical. At these stations there were no operating personnel to periodically blow off the ac-

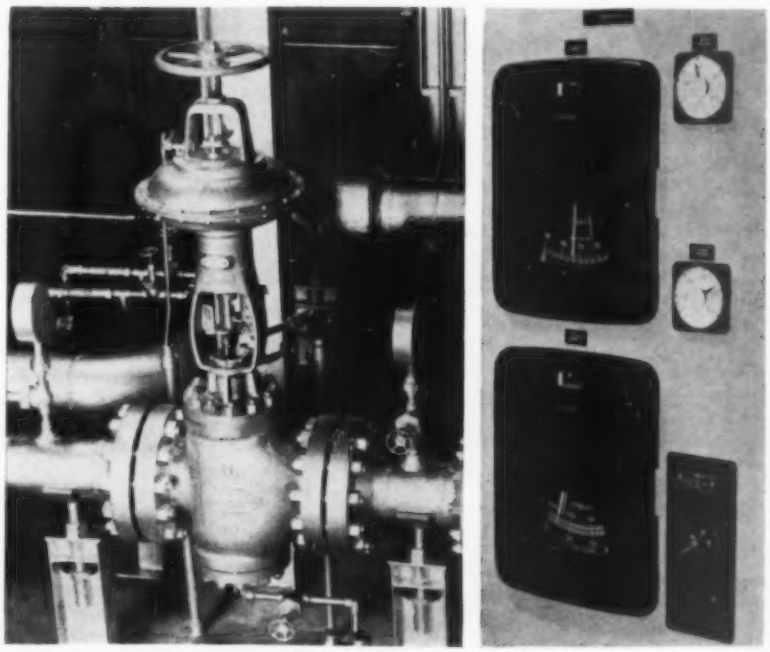


FIG. 1.

cumulated water in air transmission lines or to take over manually on the control valve when an air relay failed to operate. Instead, the station went off the line until maintenance crews could be dispatched from the controlling station some 30 to 50 miles away to correct the trouble.

In trying to alleviate this condition, the obvious thing was to get rid of air and use some type of electronic system for controlling the line. Apparently, the most sensible solution was to use the electrical signal directly to position the valve instead of converting it into hydraulic power. However, it was decided that, for Plantation service, no satisfactory or economical system of this type was available, and, therefore, an alternate system consisting of an all-electronic controller coupled with an electro-hydraulic actuator was accepted for a test installation. (See Fig. 2.)

The test installation was made in 1957 on a one-unit, 1800 hp, remotely controlled, unattended station. This was controlled through a 10-in. double-seated percentage V-port valve with rates up to 6500 bbl per hr on a 14-in. main line. It was the purpose of this installation to determine whether an electronic system of this type had control characteristics equal to that of a pneumatic system and also to study the endurance of all component parts.

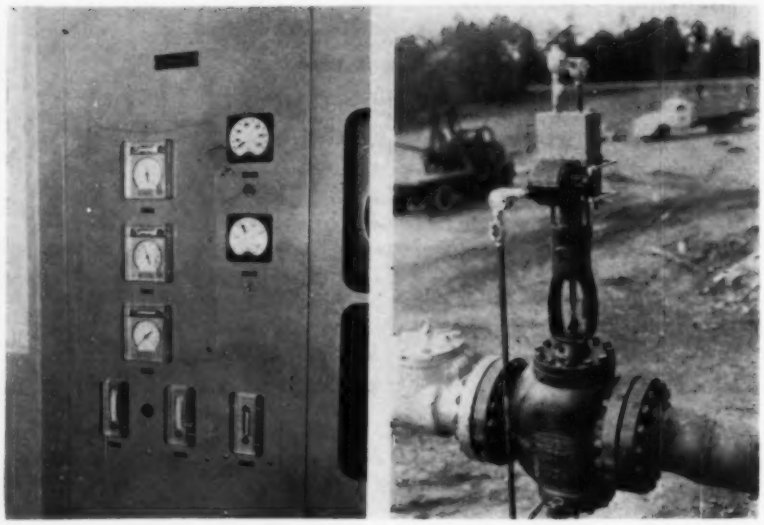


FIG. 2.

In comparing the equipment costs of a new pneumatic control system with that of an electro-hydraulic control system for control of pump suction, station discharge, and motor load, the results were surprisingly close:

Pneumatic system — including controllers, air compressors, filtering and drying equipment, pressure control switches, necessary tube and fittings and pneumatic diaphragm motor for throttle valve — approximately $4000.

Electronic system — including controllers, electro-hydraulic actuator for throttle valve, and necessary cable, conduit and fittings — approximately $4550.

This approximate 10 percent difference in equipment cost was immediately offset when installation began. The electronic system, having fewer components than the pneumatic system, naturally required fewer manhours to install.

How Control System Has Performed

Performance of this control system has been far better than expected. The electro-hydraulic actuator under maximum load conditions has stroking speeds of ⅓ in. per sec. This speed, coupled with an electrical feed-back circuit incorporated in the actuator, affords maximum response with minimum overshoot. Resolution sensitivity and dead band are better than .05 percent. Linearity of this particular actuator is within 3 percent of stroke; however, experience has proved that deviations from linearity in amounts of 7 percent or 8 percent do not impair the performance of the control action.

Electronic controllers selected for this installation are of standard manufacture and have been used in process control for several years. Physical dimensions of the instruments are miniature in design, making them applicable to control panel arrangement. They incorporate printed circuitry with plug-in features for all component parts, which simplifies maintenance and replacement. Accuracy of the control system is ± 1.5 percent of measurement span, and, coupled with the bonded strain gage type pressure transducer, has an overall accuracy of ± 2 percent of measurement span. Calibration and alignment procedures, with proper test instruments, have offered a savings in time and manpower when putting the system into operation.

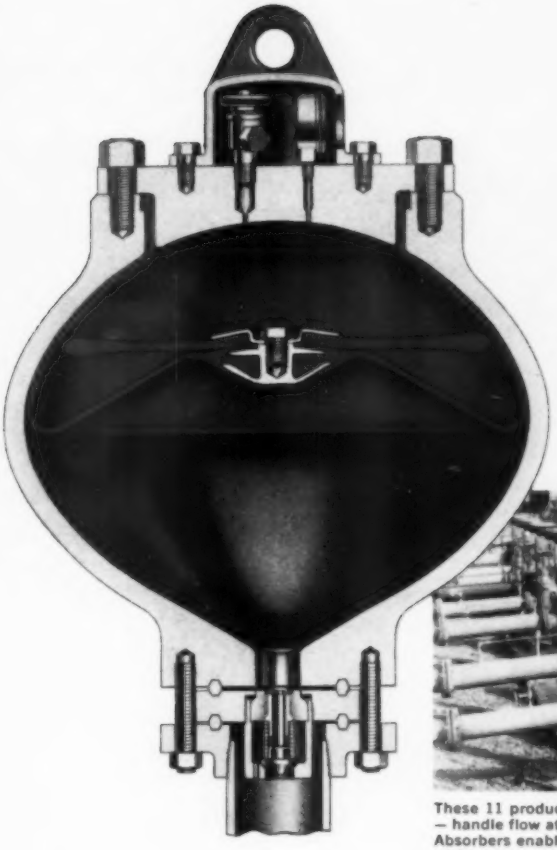
The one problem encountered in this initial installation was drifting in control instruments and erratic cycling in the actuator movement, caused by stray currents being induced in the control circuits of the control loop. Experience from this installation proved that it is practical to isolate each of the control circuits with an individual shielded cable and to ground this shield at one end only to minimize the possibility of induced currents flowing on the shield itself due to potential difference.

This installation to date has been operating almost continuously for 16 months. Only maintenance required by the electronic controllers has been routine calibration checks, and replacement of two tubes and one fuse. The electro-hydraulic actuator has required the replacement of a differential transformer, which is located in the feedback circuit, and a "torque motor," which is the prime mover for a four-way valve directing hydraulic fluid to

William Massey joined Plantation Pipe Line Company in 1947 as a junior draftsman shortly after his separation from the U. S. Navy. He has performed various engineering assignments in the office and has served as resident engineer and chief inspector during pipeline and pump station construction. Since joining Plantation he has obtained the BCS degree in industrial relations from the Atlanta division of the University of Georgia. He is presently assigned in the research section of the Engineering Department and devotes much of his time to instrumentation work.

Massey is married and the father of two children. He was born in Yonkers, New York, 33 years ago; but when he was three, his family moved to Atlanta, Georgia, where he has lived except for the time he was in the military service.

prolongs life of pipelines, fittings and pumps... saves downtime... cuts maintenance costs!



These 11 product transfer lines — some over 1,000 feet long — handle flow at the rate of 1,600 gpm each, yet Hydril Surge Absorbers enable them to be closed in a fraction of a second without over-pressuring lines, fittings or metering equipment.

HYDRIL TYPE "K" SURGE ABSORBER

smooths out shock and pulsation in pipelines

QUICK-CLOSING VALVES and piston-type pumps punish pipelines by imposing sudden peak pressure loads. Unless these surges can be absorbed or smoothed out, pipe and fittings are exposed to stresses which may cause costly failure.

Hydril Type "K" Surge Absorbers are successfully controlling many types of line surge and pulsation in petroleum product handling lines, water pumping systems and oilwell repressuring programs. Simple design and construction assures long, trouble-free operation. This same oil field-proven Hydril design has been used for many years as a pulsation dampener on high-pressure oilwell mud pumps. Servicing, though rarely required, is readily performed without special tools and without shutting down the system or removing the unit from the line. Available in a wide range of sizes and pressure ratings.

Another dependable Hydril pressure-control product

HYDRIL COMPANY

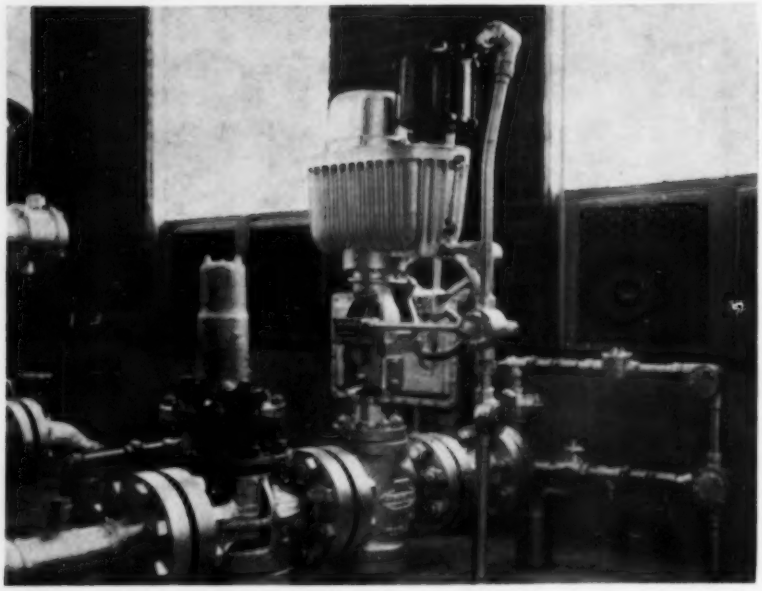


FIG. 3.

the ram. Both of the actuator failures occurred within the first month of operation.

Other Installations Made

Plantation was so impressed with the possibilities and performance of this control system used in the test installation that plans were made in 1958 to install five additional systems. The largest was at Collins, Mississippi, where three of the control sytsems were installed, one on each of three main lines served by this station. The combined horsepower controlled at the station is 8400, with an average throughput of approximately 280,000 bbl per day. This installation was completed and in operation by October 1958, and to date there have been no station shutdowns due to mechanical or electrical failure of the equipment in the control system.

The two remaining control systems were installed at remotely controlled stations on a 12-in. main line in Alabama. These were patterned after the test installation made in 1957, except that they control two series-connected pumps totaling 1200 hp. The stations were put into operation in early November of 1958 and, like the station at Collins, Mississippi, have been operating without failure to date.

Calibration of the instrumentation in the above installations has remained stable (within manufacturers' limits) in all but two instances. In both of these, drifting occurred within 24 hr after dead-weight calibrations were made. In isolating the difficulty, it was found that in both cases the trouble was due to faulty shielded cable between the pressure transducer and the instrument amplifier.

Change in Actuator Design

On a more recent installation, Plantation converted an existing 4-in. lateral line pumping station to a remotely controlled unattended pumping station. At both the controlling station and the controlled station, electro-hydraulic valve actuators of a different design were installed (see Fig. 3). The only likeness in design of this actuator and the ones previously used is that both have hydraulic rams to position the plug. Differences that interested Plantation most were: Lower initial cost, stroking action accomplished without electronic amplification of controller signal, and mechanical feed-back. Also included in this installation were electronic controllers of the same design as previously installed.

Fig. 4 shows a permanent installation of these instruments at the controlling station in Bremen, Georgia. The left half of the board contains instruments, gages, and necessary equipment to operate the 300-hp pumping unit at the controlling station; the right half provides supervision and start-stop facilities for the remotely controlled pumping unit.

These installations were completed and put into operation in January 1959 and have been operating almost continuously since. Performance of this actuator has been good. Stroking speed under full-load conditions is .37 in. per sec. Resolution sensitivity and dead band are better than .05 percent of input range, and linearity is within 2 percent of stroke.

Operating experience with this actuator indicates that for Plantation's use it would be applicable for 80 percent of the control needs, but in isolated cases where control demands are unusual, the actuator has a tendency to overshoot when the control system is subjected to a complete upset. This can be helped by changing proportional band and reset settings, but in doing so the response time of the control system is handicapped. Due to the short period of operation, it is felt that Plantation is not qualified to comment on the service life of this actuator.

As mentioned, Plantation has installed to date eight electronic control systems with electro-hydraulic actuators as final control elements. Four of these are operating in manned stations and four in remotely controlled locations. Operating and maintenance personnel alike have expressed favorable opinions as to operating qualities and calibration procedures of this equipment. ★ ★ ★

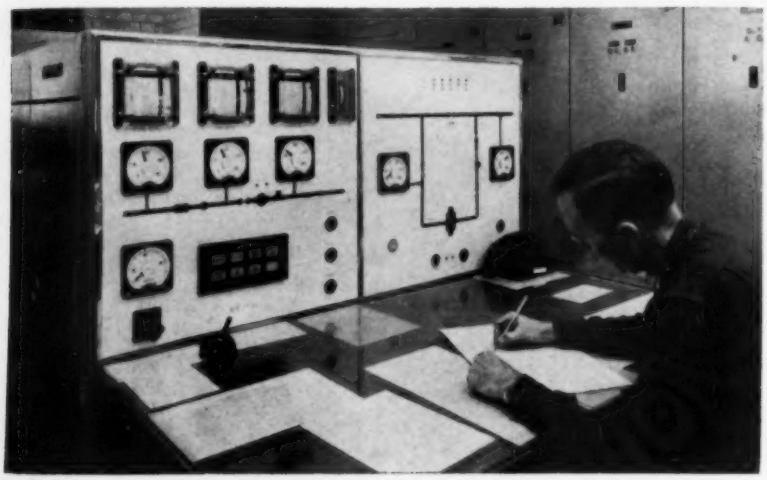


FIG. 4.

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MODEL 318 PIPELINER

WITH EXCLUSIVE TORQMATIC CONVERTER DRIVE!

★ Engineered to use engine horsepower most efficiently!

★ Built especially for the rugged demands of pipeline service!

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Digging Width from 30 to 44 inches

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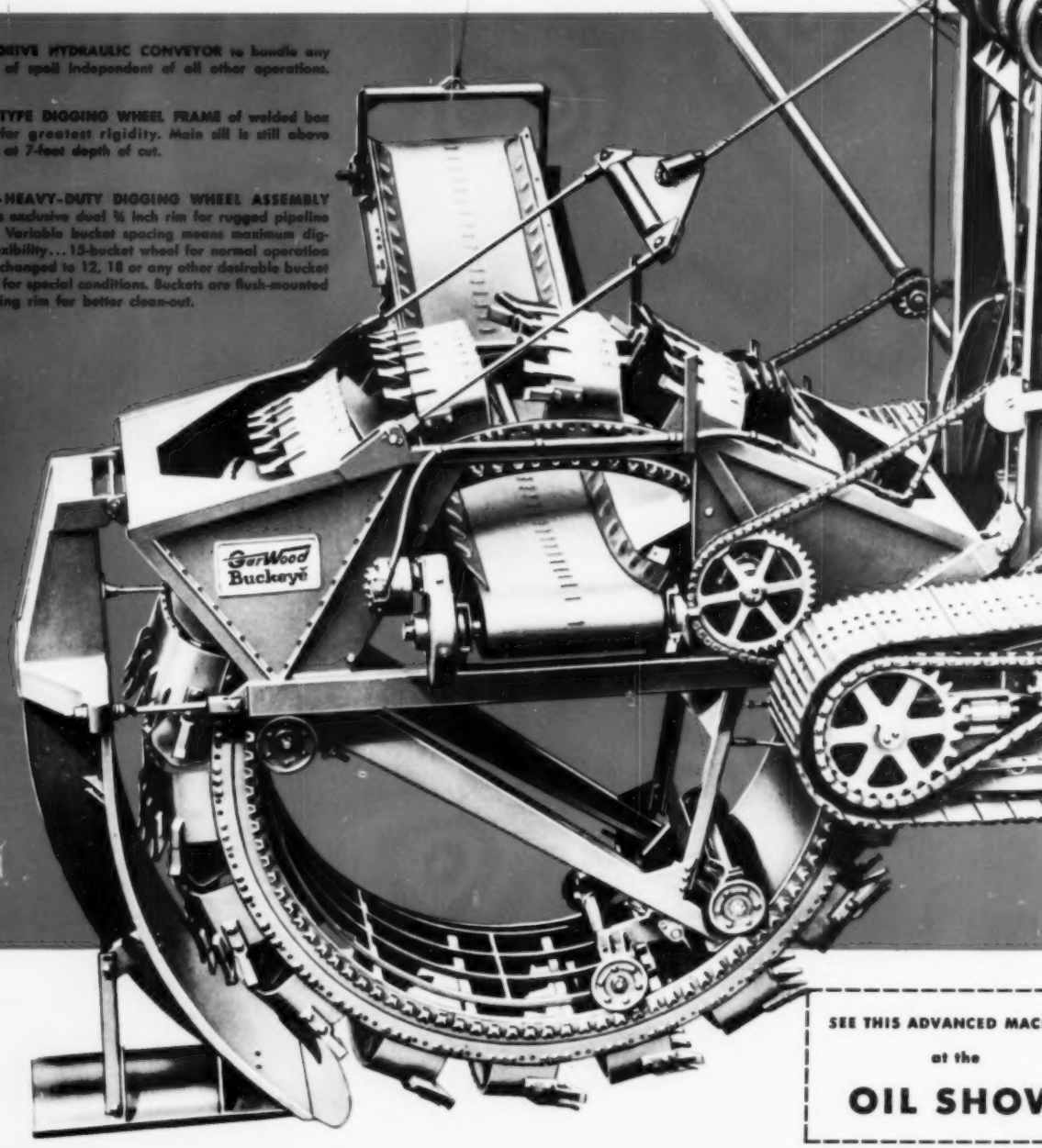
Now—from the most famous name in ditchers—an advanced high-production machine to fit 9 out of 10 pipeline jobs. It's the Gar Wood-Buckeye Model 318 Pipeliner—engineered from the ground up to handle a wide range of pipeline work more efficiently, more economically than any other ditcher ever offered. Here are the things you want and need in a pipeline machine: high production, ease of operation, transportability, job flexibility, long life, easy maintenance, engine efficiency. All these and more are yours with the all-new, all-modern 318!

DUAL-DRIVE HYDRAULIC CONVEYOR to handle any volume of spoil independent of all other operations.

TRUSS-TYPE DIGGING WHEEL FRAME of welded box beams for greatest rigidity. Main sill is still above ground at 7-foot depth of cut.

EXTRA-HEAVY-DUTY DIGGING WHEEL ASSEMBLY features exclusive dual ¾ inch rim for rugged pipeline service. Variable bucket spacing means maximum digging flexibility... 15-bucket wheel for normal operation can be changed to 12, 18 or any other desirable bucket pattern for special conditions. Buckets are flush-mounted to digging rim for better clean-out.



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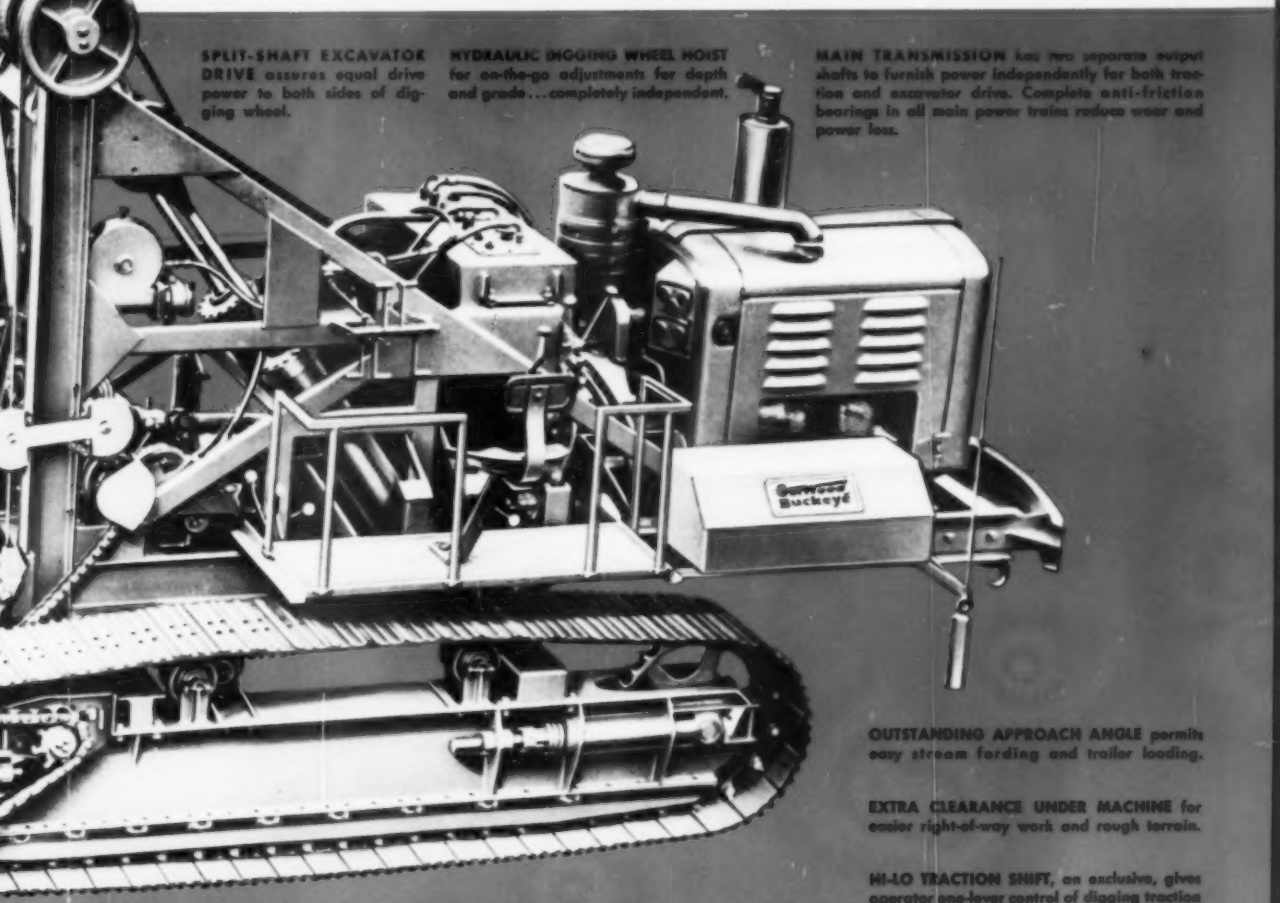
MORE WORK OUTPUT—Torqmatic Converter Drive multiplies engine torque as it's needed, up to 2½ times more workpower. Power is delivered with optimum engine efficiency, without harmful engine lugging and stalling. Because the engine works "easier", maintenance and fuel costs are greatly reduced.

EASIER OPERATION—Torque converter with tail shaft governor gives you automatic adjustment of power to load requirements, and, in addition, gives the operator 40% range within each gear selection. Production efficiency is maintained and operator fatigue reduced.

LONGER EQUIPMENT LIFE—Torqmatic Converter Drive provides a hydraulic cushion that absorbs the shock of sudden loads. By elimination of damaging impact loads, life of the entire machine is greatly extended.


SPLIT-SHAFT EXCAVATOR DRIVE assures equal drive power to both sides of digging wheel.
HYDRAULIC DIGGING WHEEL HOIST for on-the-go adjustments for depth and grade... completely independent.
MAIN TRANSMISSION has two separate output shafts to furnish power independently for both traction and excavator drive. Complete anti-friction bearings in all main power trains reduce wear and power loss.
OUTSTANDING APPROACH ANGLE permits easy stream fording and trailer loading.
EXTRA CLEARANCE UNDER MACHINE for easier right-of-way work and rough terrain.
HI-LO TRACTION SHIFT, an exclusive, gives operator one-lever control of digging traction speeds independent of all other operations.
TRUE TRACTOR-TYPE CRAWLERS—the same as you'll find on rugged earth-moving equipment for maximum traction, exceptionally long life.
SIMPLIFIED GROUP CONTROLS for easier operation, greater production. All controls at the operator's fingertips.

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Only Gar Wood-Buckeye offers features like these as Standard Equipment: fuel capacity for a full day's operation... only two components require daily lubrication... exclusive single wheel-hoist cable reduces cable replacement expense... exclusive auxiliary drive provides "live" hydraulic power for optional equipment... self-adjusting conveyor to handle spoil at any depth... unit construction of major assemblies to save maintenance time.

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INDUSTRIES, INC.
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Pipeline to Refinery Custody Transfer Streamlined

Humble's installation at Baytown has lowered labor and maintenance costs, reduced contamination and evaporation losses

G. E. Paterson, *Senior Engineer*
Technical Department, Humble Pipe Line Company

B. A. Campbell, *Associate Engineer*
Southern Division, Humble Pipe Line Company

DURING 1958, Humble Pipe Line Company and Humble Oil and Refining Company completely revamped their respective delivery and receiving facilities at the latter's Baytown refinery for "over-and-short" charging of distillation units.

THE PROBLEM:

1. High labor cost caused by manually switching and sampling eight incoming crude streams and manually gaging the refinery's receiving tankage.
2. High maintenance and contamination expense caused by complex filling system.
3. High tank filling and breathing losses caused by the number of "working" tanks.

THE SOLUTION:

1. Pushbutton switching and automatic sampling of incoming streams to reduce labor costs.
2. Metering refinery deliveries to reduce labor costs and storage requirements.
3. Separating fill lines and unitizing storage to reduce vapor losses and contamination.

Humble Pipe Line Company's crude oil metering installation at Baytown is shown schematically in Fig. 1. This drawing shows that the Satsuma, Webster No. 2, Webster No. 3, Hull, Anahuac, and Cedar Point streams may now "feed" the MSC (mixed sweet) filler simultaneously. This line mix can be credited with more uniform composition of crude fed to the distillation units. In addition to the crude oil deliveries to six refinery "tank batteries", the facilities include two fill lines, each three miles long, to ship loading tankage, and a three-stream butane-propane PD meter unit constructed in 1948.

DESIGN CONSIDERATIONS AND CHECK LIST

1. Centralize semi-automatic controls in control house for one-man operation. If remote equipment should fail, the operator can perform job manually.

2. Select equipment with safe working pressure. Maximum meter pressure during delivery to the dock tank farm is 200 psi (maximum static pressure on any incoming line is 100 psi). Working pressure equipment of 230 psi was used.

3. Protect each incoming stream with a reliable pneumatic loaded relief valve. As the relief tank is small, any relieving stream must have a visual and audible alarm.

4. Provide remote reading pressure gages for all incoming streams.

5. Install back pressure control if required to keep line packed. The Satsuma 20-in. is the only line requiring back pressure to prevent line drainage (90 ft static). Although automatic equipment such as a flow actuated switch and a pneumatic loaded top works for the 20-in. check valve could have been used, the Baytown operator manually "shuts off" the line with a motor operated manifold valve when notified by Satsuma.

6. Indicate gravity changes on all streams handling different grades of crude. The 20-in. line handling seven crude grades, one or more daily, had a remote (3½ mile upstream from the manifold) and a local instrument installed in 1956. This successful installation indicated that only remote installations would be required on the three smaller streams, handling fewer batches.

7. Provide adequate operating PD meters with one spare, for maximum throughput of each stream. Meters of 2000 gal per min were used for the larger streams to simplify maintenance and reduce the number of spare parts.

All meters are equipped with automatic temperature compensators (correcting for the weighted average gravity of stream) and counters reading to 1/100th bbl. The meters for each system have a mechanical accumulator, impulse transmitter, solenoid and hand operated shifter with limit switches, and dual counter ticket printers reading in whole barrels. Ticket printers located in the control house were considered but cost of a fail safe electric transmission system could not be justified.

8. Protect meters with vertical type strainers.

9. Install soft seated check valves on all streams to protect against reverse flow and oil loss, especially when line mixing takes place at the manifold.

10. Equip each system with a dependable proportional sampler and mixing device to assure a homogeneous fluid at the sample tap. Each sampler has dual receivers to allow sample testing at a convenient time.

11. Design manifold for switching of streams. All valves were equipped with electric motor operators for remote control. The manifold is constructed of short barrels and spaced properly to facilitate future additions and changes.

12. Provide approved type meter proving facilities. A 125-bbl, upper and lower neck atmospheric prover, internally coated with epoxy and externally insulated with cork-asphalt was installed for calibrating 2000 gal per min meters. The lower tank neck is equipped with straightening vanes and both necks have liquid level sensing device connections for future testing of "running start and stop" electronic proving. A 9-second opening and closing motor operated lubricated plug valve was installed at the prover for starting and stopping flow when using either method of calibrating.

A 2000 gal per min master meter complete with geared calibrator or adjuster driving a "Gross" counter and an automatic temperature compensator driving a "Net" counter was provided for:

(a) Master meter calibration of all 2000 gal per min meters.
(b) Measurement of crude deliveries from the relief tank to the refinery.

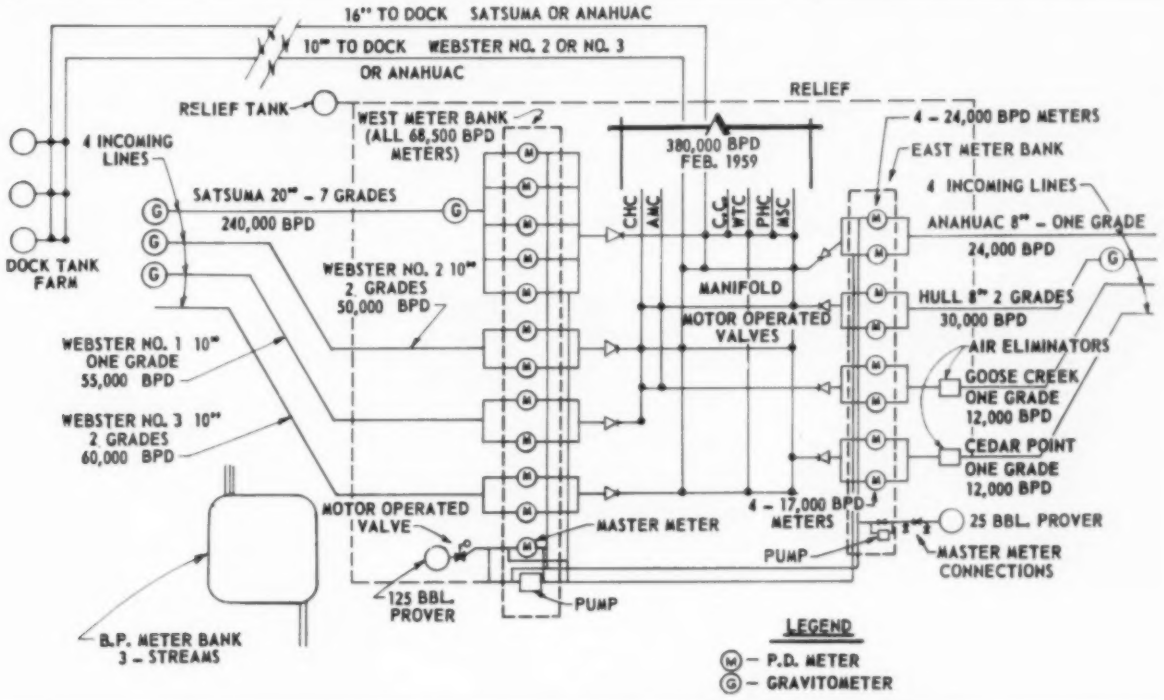


FIG. 1. Schematic diagram of Baytown metering station.

(c) Spare meter when an operating meter's internal element is removed for repair.

Smaller size meters have a separate 25-bbl double deck, internally coated and externally insulated, atmospheric prover. Connections for providing portable or trailer mounted meters are installed at this calibration tank.

13. Construct simple control board. The control panel uses a raised buss-type flow diagram, which allows changes without damage to the surface. A control wall was used to provide ample space for additions and to simplify maintenance.

14. "Build in" safety. (a) The control building, which houses non-explosion-proof electric equipment is located 150 ft from the nearest part of the crude metering installation and 420 ft from the butane propane meter bank. (b) All electrical devices at the meters and manifold are explosion-proof type. (c) Heavy material handling equipment is installed to move meters, meter internal elements, and strainer baskets or covers. (d) Air pressure and air operated tools have been provided for meter maintenance and for operation of gate valves.

Follow the Flow

The control wall, which is a facsimile of the metering set-up, and details of the associated equipment, are pictured in Fig. 2.

Gravitometer and Batch Alarm

API gravity of such stream handling batches is monitored by recording gravitometers, located 2 to 3½ miles ahead of the meters, and telemetered to continuously recording receivers on the control wall. The Satsuma stream has a second gravitometer located at the meters and has a two-pen receiver.

Each receiver is equipped with an adjustable high-low electronic vane that actuates a red, batch-change light and an audible alarm when an interface passes the remote detection point.

The Satsuma stream is switched when the pattern of the local instrument reaches the mid-point of the batch interface, as determined by interpretation of the remote instrument reading. The other streams are switched when the remote meter reading equals line displacement from the remote signal point.

Gravitometers also are used to detect high BS&W "slugs". The refiner's over-and-short feed system has a "dry feed tank" but also has a limit of the amount of water that can be handled. Dangerous amounts of water must be detected and disposed of before they reach the "stills".

Pressure Relief Alarm

Each system has a red light and audible alarm, which is activated by an explosion-proof micro switch. This switch is operated by an adjustable cam connected to the clapper shaft of a soft seated check valve downstream from a pneumatic loaded relief valve. The check also "doubles" as a shut off valve if the relief valve needs maintenance. Oil level in the relief tank is maintained as low as possible to minimize contamination between crude grades and to provide maximum "room" for relieving the 10,000 bbl pr hr Satsuma stream.

Pressure Gage

Each system has a pneumatic pressure transmitter upstream from the meters, which transmits incoming line pressure to a receiver gage on the control diagram. Line pressure indicates to an experienced operator:

(a) If a meter factor compressibility correction should be used for a "dock" delivery;
(b) A possible failure of a "dock" line when pressure drops and flow remains unchanged;
(c) A strainer stoppage and possible meter trouble when pressure increases.

Sampler Tank Selector and Sampler

Selector switches, labeled "Tank No. 1" and "Tank No. 2," and lights to indicate the tank being filled, are located in the flow diagram.

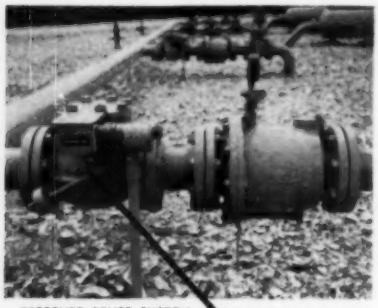
The automatic pipeline sampler pictured in Fig. 2 and shown schematically in Fig. 3 is a gas-operated, clean-oil displacing type with two containers.

Solenoid valve "C" is paced by an electric impulse transmitter mounted on the meter accumulator system. Two horizontal sample taps are installed into the center of the pipeline downstream from a orifice plate. Crude oil is routed at pipeline pressure into one of the two sample chambers through solenoid valves that are operated from the control wall. Crude oil flow is limited by movement of the piston separating the sample from the clean oil. Piston movement is controlled by the rate at which the gas-operated slide-valve and measuring chamber "E" allows clean oil to flow from the cylinder into the reservoir. This rate of flow can be controlled by changing the stroke of the floating piston measuring chamber.

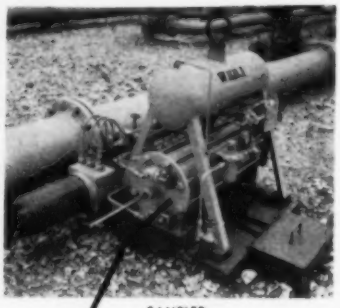
Samples are displaced from the chamber into a light weight can by applying gas pressure to the clean oil reservoir with valve "B" and then opening valve "H". The composite sample is mixed thoroughly then a representative sample of the composite sample is tested in a heated centrifuge to obtain BS&W content.

Meters, Remote Counter and Ticket Selector

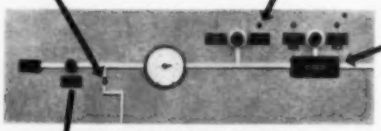
Deliveries through each system are measured by low head loss, sliding vane type, PD meters, operating at 60 to 80 percent of their rated capacity. The Satsuma 20-in. stream, for example, is



PRESSURE RELIEF SYSTEM

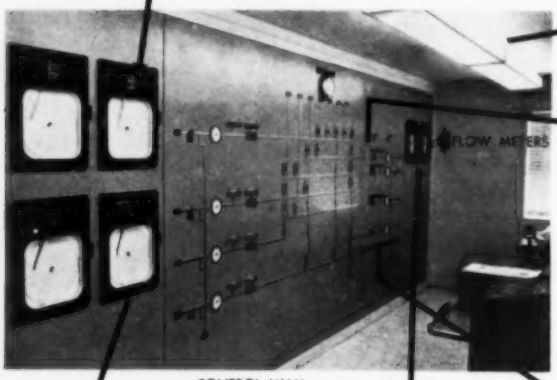


SAMPLER

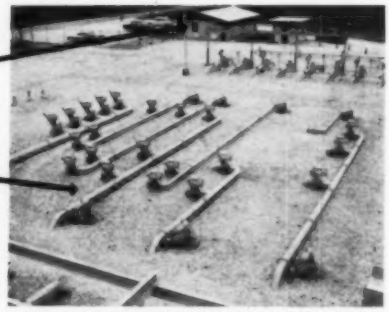


DETAIL OF CONTROL DIAGRAM

WEST METER BANK WITH 125 BBL PROVER

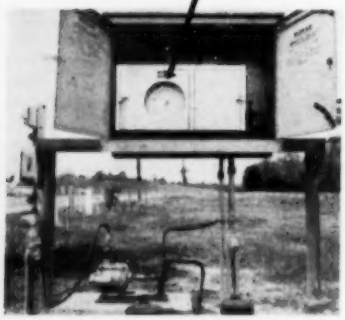


CONTROL WALL

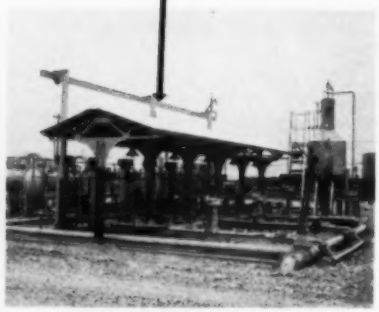


MANIFOLD WITH SAMPLERS AND CONTROL HOUSE

EAST METER BANK WITH 25 BBL PROVER



REMOTE GRAVITOMETER



BUTANE-PROPANE METER BANK

FIG. 2. The control wall, which is a facsimile of the metering set-up, and details of associated equipment.

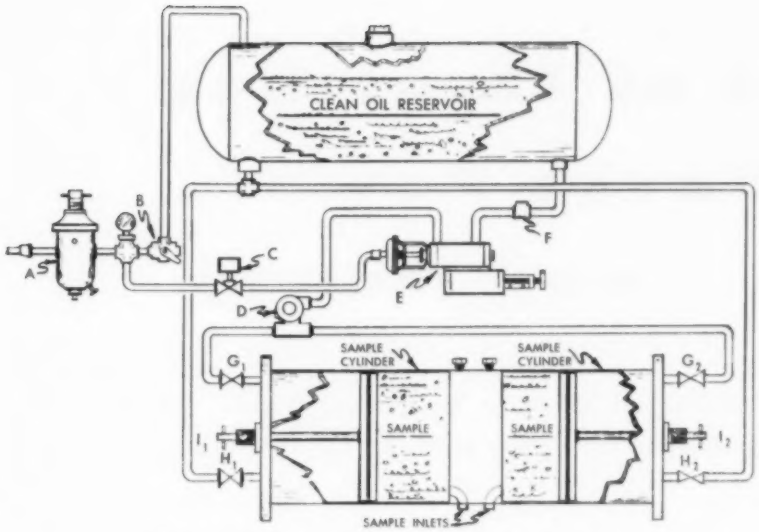


FIG. 3. Schematic diagram of automatic pipeline sampler.

measured by five 68,500 bbl-per-day meters, four of which normally operate together. A combinator system "adds" individual meter reading into one of the dual counter-ticket printers.

The impulse transmitter on the accumulator system which paces the sampler also paces the 6-figure reset counter located in the flow diagram. This remote counter registers in 10-bbl units to increase counter life.

Located on the flow diagram are ticket selector switches, labels showing "Printer No. 1" and "Printer No. 2," and lights indicating the operating counter-printer. When the selector switch is turned, a solenoid operated shifter changes the meter counter-printer and when this change is made, limit switches on the shifter energize the proper indicating light. (Each printer head has a manual shifter for emergency use.)

Fig. 2 shows how MI cable was used to connect the electrical devices on the meter accumulator system.

Switching Controls, Manifold

Selecto-pushbutton control for each valve, and valve position indicating lights, are located on the flow diagram for remote operation of motor operated double disk gate valves in the switching manifold.

Manifold valves are installed on an angle, which allows manual operation from ground level if remote operation is not possible.

A 600 gal per min electric-motor-driven rotary pumping unit is installed on the 2000 gal per min meter bank and auxiliary piping is arranged for:

(a) Pumping crude from the 125-bbl prover into the proper fill line;

(b) Pumping a crude grade from the relief tank into the proper fill line;

(c) Pumping crude from any incoming system into the proper fill line.

Meter Proving

All meter provings are in accordance with API Standard 1101 on positive displacement meters and all provings are witnessed and accepted by a representative of the refinery. The 2000 gal per min meters are proved with a 125-bbl volumetric prover tank or by the master meter. As an example, one line meter and the master meter are proved simultaneously on each crude grade by using the tank. Then the other line meters are proved by running them in series with the master meter.

A new electronic system is being installed that yields accurate provings much quicker with less effort. This system consists of liquid level detectors installed in both the top and bottom necks of the 125-bbl prover; a 1000 pulse per bbl generator, mechanically driven by the meter; an electronic switch or "pulse gate," opened and closed by the level detectors; and an electronic counter capable of counting the fast pulse rate generated by the meter. The upper liquid level detector will close the pulse gate and initiate the closing of the 9-second motor-operated prover tank valve. With this arrangement meter proving will be made "on the run". Similar equipment with a hand operated pulse gate will be installed for electronic master meter proving.

Initially, the meter proving program called for proving each meter twice each month on each grade of crude. The accumulated data showed that the seven crude grades handled through the Satsuma line could be consolidated into three groups. "Crude Group" proving is now being used and has reduced the number of individual provings from 70 to 30 per month on the Satsuma stream. Crudes of other streams probably will be grouped when more data are available.

Meter factors for the dock tank farm delivery are different from those for refinery delivery because the operating pressure of the meter may vary by 150 psi. Meters are calibrated at dock delivery pressure or a liquid compressibility factor is applied to a meter factor established at a lower operating pressure.

The smaller meters on the East meter bank are calibrated with the 25-bbl prover. This tank, with portable master meter connections, has also been used to prove four portable PD meter units used in field gathering operation. Baytown is ideal for proving portable equipment because all crude grades are available.

Operation of Equipment

The samplers have operated satisfactorily but have required considerable maintenance. Most of the trouble is connected with the mercury switch in the electrical impulse transmitter on the meter combinator, malfunction of light duty relays in the pulsing circuit, and stoppages of the solenoid valves that switch the sample containers. The solenoid valves will be removed from the crude line to the container installed on the clean oil line from the container (at G_1 and G_2, Fig. 3). Heavy duty micro switches will be installed in the impulse transmitters and continuous duty relays will be installed in the pulsing circuit.

The basic clean oil displacing type sampler has proved trouble free at a dozen other installations and can be made trouble free at Baytown.

In February 1959, a booster station was installed on the Hull 8-in line. Some of the line had to be drained and special operation at Baytown was necessary to prevent metering errors. By routing the air and oil into the relief tank and then measuring oil from the relief tank with the master meter, errors were eliminated.

The meter proving system has been trouble-free and meter factors have repeated very well during successive runs except when the stream had a high BS&W content.

Conclusion

A good metering installation is a sound investment. Overall accuracy depends on the best possible equipment, preventive maintenance of the equipment, and the skill of operating personnel. ★ ★ ★

P 615.512.3

Control of Throttling Saves Power ...and Money

Blocking off of one or two pump stages reduces by 60 percent power required for throttling

G. P. Jennings,
General Superintendent, Phillips Pipe Line Company, Products Pipeline System

IN PIPELINE WORK it is quite common to use a constant speed electric motor to drive a centrifugal pump. An automatic throttle valve is usually installed on the discharge to control intake and discharge pressures. Whenever the throttle valve operates a definite waste of power results. Various means have been used to eliminate, or at least reduce, this throttling, such as installing two or more pumps in a station with perhaps one of them half size.

It is not too difficult to avoid throttling when operating at full rate on a product of fairly constant gravity. When operating at reduced rates, however, or on a products pipeline system that handles various products from propane to furnace oils, throttling is often required.

Fig. 1 shows the capacity head curve on a typical 6-stage pump. Differentials for four and five stages are also shown. The "line pressure required curve" assumes that at a pumping rate of 60,000 bbl per day, all six stages are required and no throttling occurs. At 55,000 bbl per day only about 900 psi, or five stages of pressure, are required, and at 50,000 bbl per day only about 740 psi, or four stages, are required. Therefore, if one could remove and replace impellers at will, there would be no problem. This is, of course, impossible, however, one can "block off" one or two stages and thus save about 60 percent of the power that would otherwise be wasted by throttling.

It can be noted from Fig. 1 that at zero flow the horsepower requirement is about 560 hp or 40 percent of the 1400 hp required at 60,000 bbl per day. This same percentage, of course, applies to each individual stage.

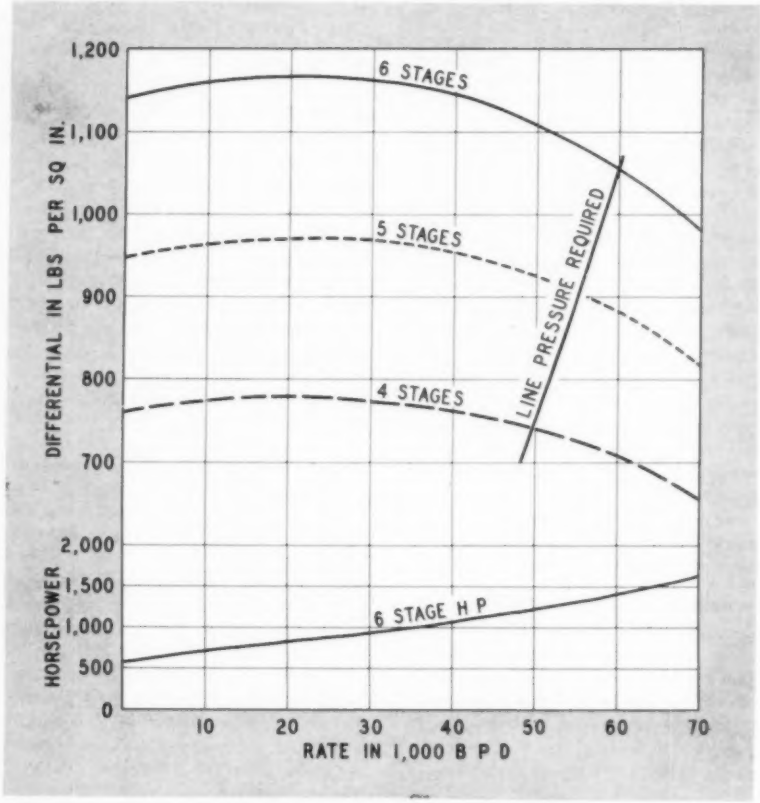


FIG. 1. Capacity head curve of a typical 6-stage pump.

How Stages Are Blocked Off

Fig. 2 shows a typical 6-stage pump installation with the conventional automatic throttle valve. The pump is provided with two discharge nozzles, the conventional one at the end of the sixth stage and an additional one at the end of the fifth stage. An electric motor-operated valve, a check valve, a differential pressure mercoid, and a reversing contactor also are provided.

The upper limit of the differential pressure mercoid is set to operate at a pressure differential somewhat in ex-

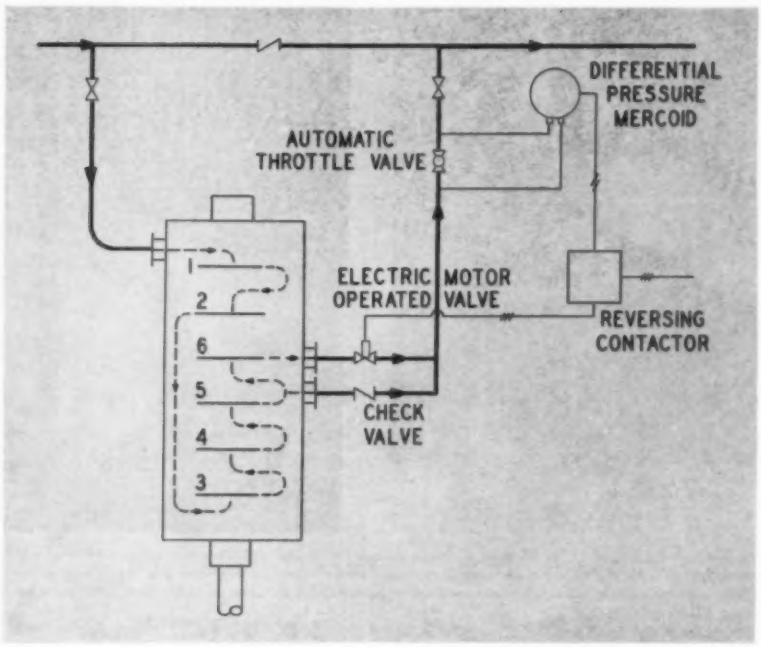


FIG. 2. Typical 6-stage pump installation with conventional automatic throttle valve.

cess of the pressure developed by the last stage. The lower limit is set to operate at a pressure differential slightly in excess of the pressure drop through the throttle valve when wide open. In operation, when the differential across the throttle valve reaches the upper limit of the setting of the differential pressure mercoid, it opens (or closes) the circuit to the reversing contactor, applying energy to the electric motor-operated valve, which closes slowly.

During this closing, the pressure on the downstream side of the electric motor-operated valve will decrease gradually and, at the same time, the differential across the throttle valve also will decrease. When the pressure on the downstream side of the electric motor-operated valve drops to the discharge pressure of the fifth stage, the check valve will open, and when the electric motor-operated valve closes completely, the last stage is cut out.

The throttle valve is now throttling the discharge slightly. When the last stage of pressure is again required, the throttle valve will start to open, and when the throttling differential drops to the setting of the lower limit of the differential pressure mercoid, it will close (or open) the circuit, and conversely to the above operation the electric motor-operated valve will open and restore the last stage to normal operation.

The additional discharge nozzle can, of course, be placed at the end of the fourth stage instead of the fifth stage and thus cut out two stages if throttling is expected to be this severe. One might think that excessive heat will develop with one or two stages blocked, however, there will be sufficient normal leakage from the blocked stages to lower pressure stages to dissipate the heat generated.

The above assumes the installation is in an unattended station and must, therefore, be automatic. If the station is manned, however, an ordinary valve can be substituted for the electric motor-operated valve and the differential pressure mercoid and the reversing contactor can be omitted. Then, the operator simply notes when excessive throttling occurs and closes the valve on the normal discharge.

How Much is Saved?

To obtain an idea of the possible savings that can be made by blocking out one stage we will assume that we wish to operate at 55,000 bbl per day with one stage cut out versus the usual method of throttling. (See Fig. 1.)

THROTTLING METHOD

(Assume $0.01 per kw-hr energy cost and 82 percent pump efficiency)

$$\frac{55{,}000 \times 1080 \times 0.000017}{0.82} = 1230 \text{ hp}$$

$$\frac{1230 \times 0.746}{0.95} \times 0.01 \times 24 = \$232 \text{ per day}$$

BLOCKING OUT LAST STAGE

Five stages:

$$\frac{55{,}000 \times 905 \times 0.000017}{0.82} = 1030 \text{ hp}$$

Sixth stage:

$$\frac{55{,}000\ (1080\text{-}905)\ 0.000017}{0.82} \times 0.40 = 80 \text{ hp}$$

All stages:

$$1030 + 80 = 1110 \text{ hp}$$

$$\frac{1110 \times 0.746}{0.95} \times 0.01 \times 24 = \$209 \text{ per day}$$

Saving:

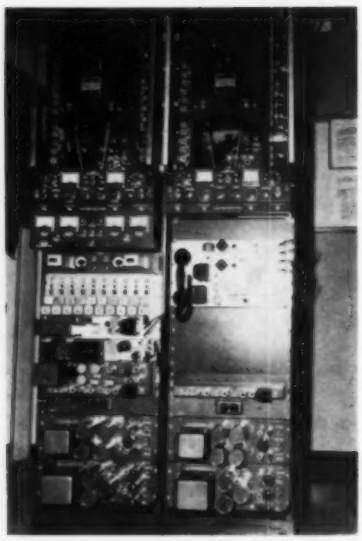
$$232 - 209 = \$23 \text{ per day}$$

In designing a new pipeline or an unattended station it may appear that the saving will not justify the cost of the additional equipment; however, operating conditions frequently change and may thus require much more throttling than anticipated in the original design. It might, therefore, be wise to provide an additional discharge nozzle on the new pump, which can be blinded off and used later if required. An alternate method would be to install a conventional valve on the normal discharge and a check valve on the second discharge. Then, if conditions change and are likely to require throttling for an extended period, one stage could be blocked out by simply closing the valve on the normal discharge. ★ ★ ★

The Author

G. P. Jennings *is general superintendent of the Phillips Pipe Line Company products pipeline system. For the last 20 years, he has been actively engaged in pipeline operations, and before that spent eight years in the general engineering department on design and construction of pipeline facilities. He served in the zinc industry as design engineer and also was a service engineer on locomotive feed-water pump and feed-water heater problems. Jennings obtained his mechanical engineering degree from Rensselaer Polytechnic Institute.*

Communications building at Joliet, Illinois. Antenna in center on roof is part of Natural's RF terminal at point of interconnection with the Texas Illinois microwave system, for extending Natural's channels into Chicago. Line rigged at base of tower is for raising third reflector.



RF terminal equipment at Joliet including power and control equipment and baseband order wire. All stations are equipped with full duplicate standby RF equipment arranged for bi-lateral switchover.

Combination Microwave-Wireline Solves NGPL's Communication Needs

New installations increase service for VHF mobile relay, data transmission, telemetering, supervisory control and voice communication

C. E. Upson
General Superintendent of Communications
Natural Gas Pipeline Company of America

ON MAY 1, 1959, Natural Gas Pipeline Company of America will begin operation of its newly constructed and modernized communications facilities between Chicago, Illinois, and Amarillo, Texas.

Natural has always recognized the importance of fast, reliable communications in the operation of its long-haul pipeline systems. Speed in handling gas dispatching and production orders, in reporting and advising those concerned of emergency conditions, and in dispatching men and equipment in connection with pipeline repair work is an important factor in assuring an uninterrupted supply of gas to our markets.

Since construction of its first high-pressure gas transmission system in 1930-31 to deliver gas to markets in the Chicago area from the Texas Panhandle fields, Natural has operated and maintained a company owned wireline communications system between its general offices in Chicago, production offices in Amarillo, and all intermediate compressor stations. These wire facilities, as initially constructed, represented a modern and reliable means of effectively controlling system operations.

By 1938 operations were becoming more complex and Natural installed AM radio base station transmitters and receivers at each compressor station, and mobile receivers in cars and trucks of key field personnel. This equipment provided excellent emergency "point-to-point" communications between compressor stations for relay of urgent operational traffic at such times as our wire lines were inoperative due to sleet, wind, or electrical storm damage. It also provided a means of relaying messages to mobile units. The base station equipment was further arranged to be transported to and operated as a two-way message service at field locations where major pipeline repair work required.

These radio facilities gave way to more modern VHF base and mobile equipment in 1947-48 and Natural is presently operating 16 VHF base stations and 165 VHF mobile units.

More Channels Needed

Operating requirements in recent years created the need for additional channels of communication along the pipeline route. These channels must accommodate services such as VHF mobile relay, data transmission, telemetering, supervisory control, etc., as well as voice communications.

Natural elected to meet these re-

quirements in the following manner (reference general system map):

1. Construct a microwave radio relay system between Chicago, Illinois, and station 106, Beatrice, Nebraska, to replace wire lines in this area.
2. Install four channels of telephone carrier on Natural's existing wire lines between Beatrice, Nebraska, and station 111, Fritch, Texas.
3. Install two channels of telephone carrier on Natural's existing wire lines between Fritch and Amarillo, Texas.

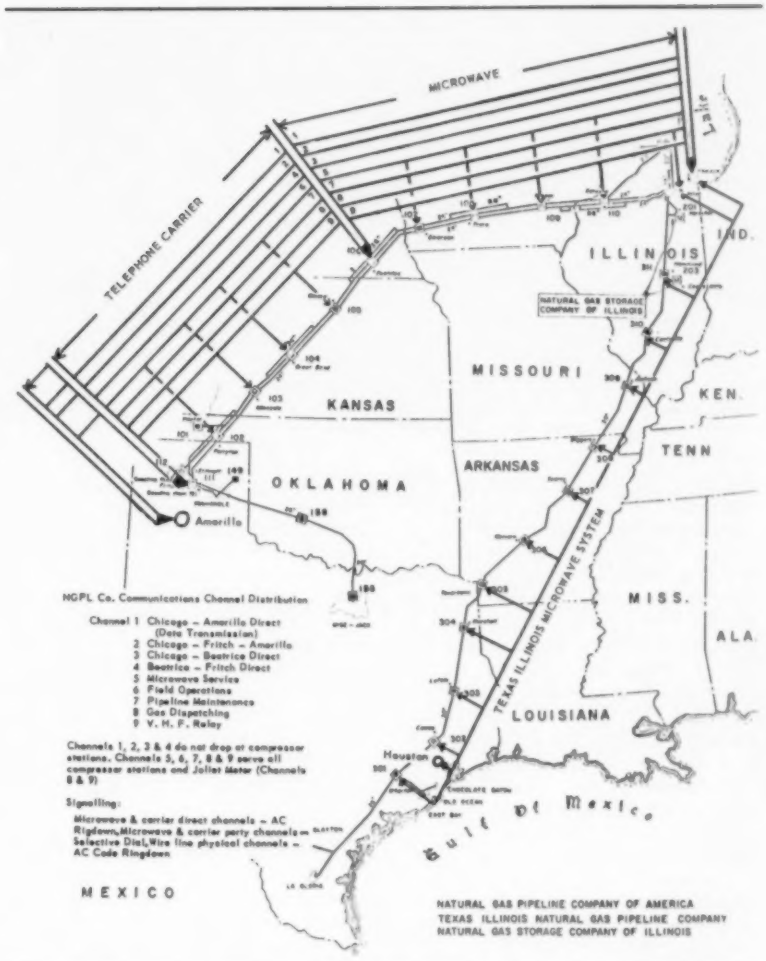
Natural selected FM multiplex equipment for the "direct" full duplex channels and single side band multiplex equipment for the selective dial "party" channels. The service channel operates on the RF base band.

The telephone carrier equipment is four channel between Beatrice, Nebraska, and Fritch, Texas, and three channel (two installed) between Fritch and Amarillo, Texas.

These facilities provide the following channels as initially installed (reference general system map):

Direct Channels:

1. Chicago-Amarillo. This channel is arranged to interconnect IBM card-to-card data transceivers as well as for voice communications.
2. Chicago-Fritch-Amarillo
3. Chicago-Beatrice
4. Beatrice-Fritch


MICROWAVE
TELEPHONE CARRIER
ILLINOIS
MISSOURI
KANSAS
OKLAHOMA
ARKANSAS
KEN.
TENN
MISS.
ALA.
LOUISIANA
Amarillo
Houston
TEXAS ILLINOIS MICROWAVE SYSTEM
Gulf of Mexico
MEXICO
NGPL Co. Communications Channel Distribution
Channel 1 Chicago – Amarillo Direct (Data Transmission)
2 Chicago – Fritch – Amarillo
3 Chicago – Beatrice Direct
4 Beatrice – Fritch Direct
5 Microwave Service
6 Field Operations
7 Pipeline Maintenance
8 Gas Dispatching
9 V. H. F. Relay
Channels 1, 2, 3 & 4 do not drop at compressor stations. Channels 5, 6, 7, 8 & 9 serve all compressor stations and Joliet Meter (Channels 8 & 9)
Signalling:
Microwave & carrier direct channels – AC Ringdown, Microwave & carrier party channels – Selective Dial, Wire line physical channels – AC Code Ringdown
NATURAL GAS PIPELINE COMPANY OF AMERICA
TEXAS ILLINOIS NATURAL GAS PIPELINE COMPANY
NATURAL GAS STORAGE COMPANY OF ILLINOIS

General system map showing complete communications system including new installations.

Typical RF equipment installation (westbound) at one of 11 unattended intermediate repeater stations.

Party Lines:

5. Microwave service
6. Field operations
7. Pipeline maintenance
8. Gas dispatching
9. VHF relay

These installations will increase Natural's field communications system from 3540 channel miles to 8065 channel miles of service. This system, through the switchboard in the Chicago office, may be interconnected to the microwave field communications systems of Texas Illinois Natural Gas Pipeline Company and Natural Gas Storage Company of Illinois providing these combined companies with an integrated communications system of 16,180 channel miles of service.

Microwave Construction

The microwave system required construction of 16 complete microwave stations between Beatrice and Norway, Illinois, a microwave terminal at Joliet

The Author . . .

C.E. Upson *is general superintendent of communications for Natural Gas Pipeline Company of America, Texas Illinois Natural Gas Pipeline Company, and Natural Gas Storage Company of Illinois.*

Following his formal education, Upson worked two years with the Lincoln Telephone and Telegraph Company of Lincoln, Nebraska. In 1938 he was employed by Natural Gas Pipeline Company of America to assist with the operation and maintenance of its wireline communication facilities and installation of its special emergency radio facilities. He has remained in the employ of the above affiliated companies since that time and has held positions of district lineman, field communications construction superintendent, superintendent of communications, and general superintendent of communications. In his present position he has charge of the construction, operation and maintenance of all communication facilities and services used by the operating companies.

Typical equipment building at unattended repeater. Structure has partition to provide an insulated room for electronic equipment and a non-insulated room for emergency power plant, transfer panel, load center, tower lighting control, and voltage regulating transformers.

Single guyed microwave tower mounting two 10-ft by 15-ft reflectors at repeater station.

using existing Texas Illinois building and tower, and installation of channelizing equipment only in Chicago.

This system operates in the 6575-6875-mc band. Each repeater station requires microwave transmitters and receivers to pick up, amplify and retransmit the signal. Each compressor station, Joliet and Chicago, requires channelizing equipment to drop the voice channels used at those points. All stations are equipped with full duplicate standby transmitters, receivers, and power supplies, which automatically switch into service and take over system operation in event of failure of the main equipment.

All stations are equipped with an engine driven emergency power generator to take over the power load whenever primary power fails.

The towers range from 200 to 310 ft in height (average 280 ft). All towers are painted and lighted according to CAA specifications. The average path length is 30 miles, the longest being 41 miles, the shortest, 6 miles.

The system is equipped with alarm facilities to notify maintenance personnel of failure of tower lighting, switch-over of electronic equipment, or switch-over of power equipment.

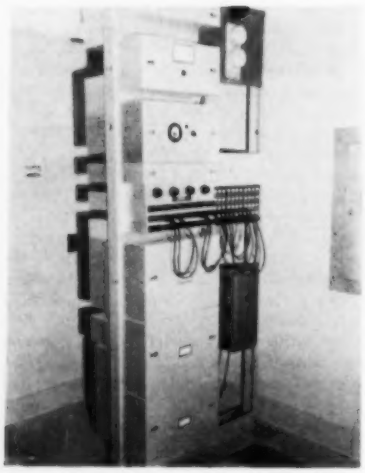
All matters dealing with FCC and CAA authorizations, land, road, power, building and tower inspection, station cabling, fuel lines, and telephone equipment installations are being handled by company forces. The topographical survey, equipment installation, path alignment, tuning and testing is being performed jointly by company and field engineers of the microwave equipment supplier.

Telephone Carrier Construction

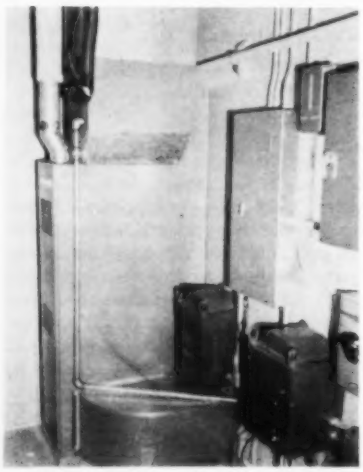
Telephone carrier construction required installation of electronic equipment, plant and office cabling, and telephone equipment at Amarillo and Stations 111, 102, 103, 104, 105, and 106. Transmission tests indicated a four-channel carrier system could be installed without major rework of wire lines. It was necessary to construct a special carrier frequency cable across the Cimarron River and to retranspose our wires on poles in the city of Amarillo. All of this work has been planned and performed by company forces.

This equipment includes automatic pilot regulation to maintain system stability during changes in temperature, rainfall, etc., affecting transmission.

Special features include arranging of one Chicago-Amarillo channel to interconnect IBM card-to-card transceivers. Another feature is the VHF radio channel, which will permit communication with any of our radio equipment vehicles or aircraft from any point on the system. The feasibility of both of these operations has been proved on the Texas-Illinois system. * * *



Telephone carrier equipment and wireline terminations at Beatrice terminal.



Combination air-conditioner and furnace at Beatrice, Nebraska. All microwave equipment rooms are air conditioned, and, at multiplex points, are heated. Power panel at right includes power and voltage regulating transformers and load center.

Emergency standby power generator installation arranged to automatically take over station load in event of failure of primary power.

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GRAPHIC ENGINEERING DIGEST

Uprate ASA 300 Flanges for Liquid Service

J. W. Squire, *Research and Development Engineer, Service Pipe Line Company, Tulsa, Oklahoma*

IT'S TIME we were taking a second look at flanges. There are a number of advantages in using an O-ring seal with a flat-face flange for the ASA 300 welding-neck series up to the 24-in. size. From calculated stress standpoint it is often possible to uprate ASA 300 flanges to a higher pressure rating for this service than indicated in the ASA standard.

Standards for flange design. The ASA B16.5 code now has seven pressure-rating classes varying from 150 psi to 2500 psi and ranging in size from ½ in. to 24 in. There are several different facings and four basic types — welding neck, slip-on, lapped, and screwed.

For the moment we will concern ourselves with welding-neck flanges for crude and products lines at 100 F and the possibilities of using an O-ring for gasket material.

Previous tests. In 1953, my company made a series of preliminary stress calculations and tests on size 4-in. and 12-in. flanges, which compared generally the effects of using a raised-face flange and a fiber or spiral wound metal-asbestos gasket with either a raised-face or a flat-face flange grooved for an O-ring.

We concluded from these tests that ASA 300 flanges, welding-neck flat-faced, O-ring seal, in sizes up to 12-in. may be safely used for 1440 psi working pressure in crude and product service. In these smaller sizes, it is a simple matter to achieve an ASA 600 rating for an ASA 300 flange at 100 F or lower. The flanges are not stressed above the 17,500 psi allowed in the ASME Boiler and Pressure Vessel Code.

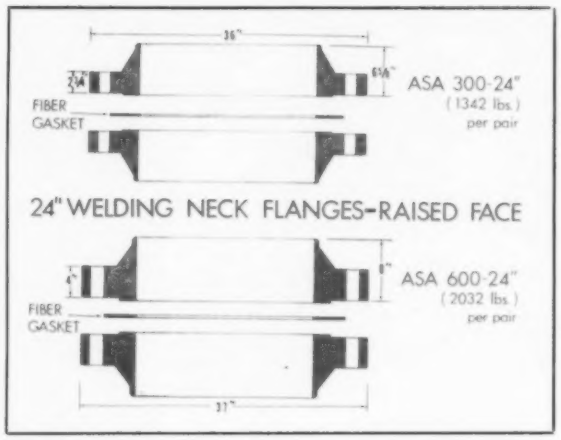

FIG. 1

What about the larger sizes – say up to 24-in.?

Fig. 2 and 3 show alternative methods for using an O-ring to replace a flat or ring gasket.

Flange design calculations. The conventional ASME Boiler Code method of flange design, based on a study by Waters, et al. is not applicable for a full-face gasket on a flat-face flange or for an O-ring grooved flat-face.

The raised face and O-ring-plate stresses are based on the boiler code design formulas. The O-ring grooved-flange stresses are calculated in accordance with the modified Rossheim theory, which has been under consideration in the ASA B16 Flange Committee for several years. This theory takes into account the restraining moment of the flange face outside the bolt circle, which serves to reduce the critical stresses in the flange.

In the normal raised-face assembly the initial bolt load must be comparatively high to produce a seal on the gasket. When an increasing hydrostatic pressure is applied, this bolt load is first relaxed and then increased until a point is reached where the flange rotates sufficiently to allow leakage. As the flange rotates excessive stresses are introduced in the adjacent pipe wall.

With an O-ring seal, using a lighter flange and, with proper

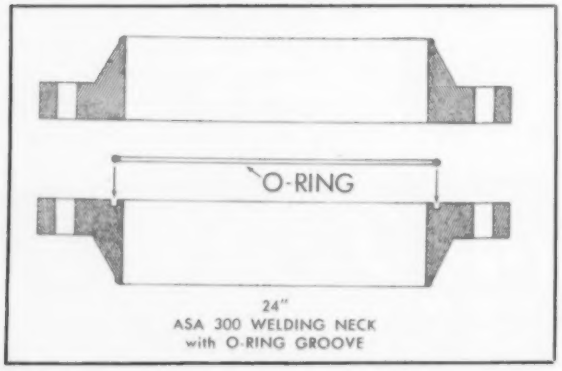

FIG. 2

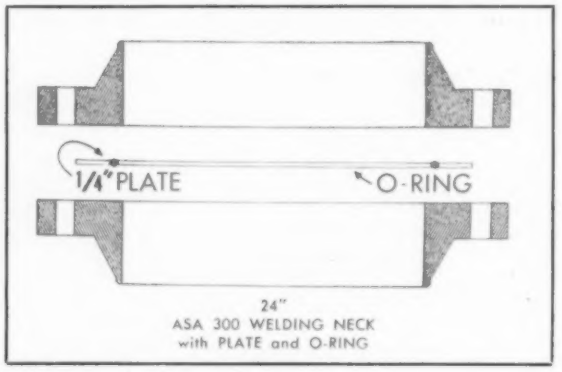

FIG. 3

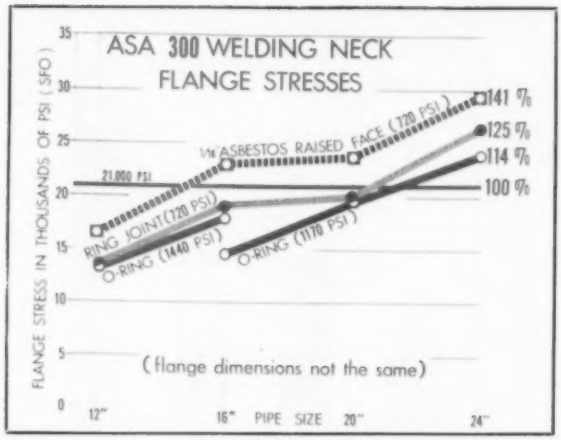

FIG. 4

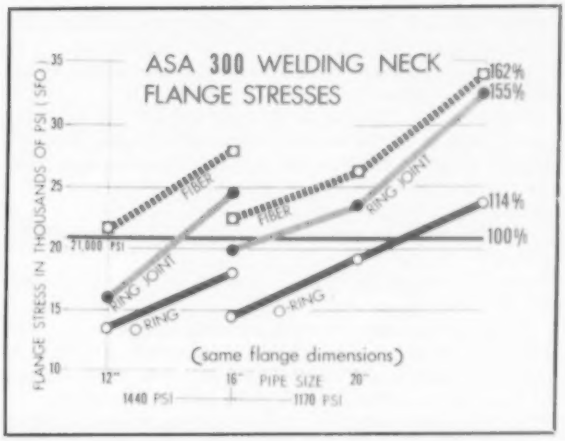

FIG. 5

design, stresses can be achieved that are more compatible with those in the piping system. A conservative approach from the stress standpoint can still be maintained.

Flange stresses. Even with a standard design, accepted by ASA B16.5, it is entirely possible to achieve stresses of more than 40 percent above a secondary rating of 21,000 psi at 720 psi internal pressure. The two top lines (Fig. 4) were taken from data published by one manufacturer in 1953. The lower broken lines are calculated values on a flat-face flange with an O-ring groove and show the effect of uprating this flange to the internal pressures shown. While this is not a direct comparison, since different dimensions were used, it illustrates the possibilities of using an O-ring. The 21,000 psi flange stress rating was indirect'y sanctioned by the ASA B16 Flange Committee, but not codified.

Direct comparisons. Values shown in Fig. 5 were calculated using the same dimensions and pipe thicknesses with different gaskets. At 1170 psi the stress in a raised face 24-in. ASA 300 with a fiber gasket is more than 40 percent greater than stress for a flange with a flat face and O-ring groove. In effect, this allows uprating the flange about 60 percent (from 720 to 1170 psi) for a 24-in. size and 100 percent (from 720 to 1440 psi) in the smaller sizes shown. The pipe wall thicknesses used are commensurate with commonly used station ratings for API 5L Grade B or API 5LX42 pipe. The critical hub length (h) is conservatively taken as ¾ in. back from the pipe end of the flange.

Note (Table 1) that both O-ring systems reduce the stresses in the flange when direct comparisons are made and that there is little difference in these stresses with either O-ring system. This is due primarily to the reduced hydrostatic end force from having the seal closer to the fluid than in the standard gasketed flanges.

Bolt stresses. Neither of the O-ring systems requires an initial bolt stress in excess of 6000 psi. The other systems assume an initial bolt stress of 20,000 psi. In the groove system, however, we have assumed that this initial 6000 psi stress is added to the operating bolt stress. In the plate system we have not made this assumption because the flange is free to rotate. This makes the bolt stress higher for the O-ring groove but still less than that for the standard gasket systems under the same operating conditions. In neither O-ring case are they excessive.

Practical Considerations

First, what happens to O-ring flanges in case of fire?

In a flange with an O-ring seal, the seal is closer to the flowing fluid and will be subjected to less heat than the seal on a raised face. Fires are fed only when leakage occurs. Leakage occurs only when there is relaxation of the bolts or distortion of the fitting. In addition, O-rings should cause no more concern from this standpoint than those in the gate

TABLE 1. Stresses (Thousands of psi) in ASA-300 Welding Neck Flanges and Bolts.

				Raised Face						Flat Face O-Ring			
				Fiber Gasket		1/16-in. ASB Comp. Gasket		Ring Joint		With Groove		With Plate	
	Size, in.	Wall (Go)	Pressure (psi)	Flange	Bolt	Flange	Bolt	Flange	Bolt	Flange	Bolt	Flange	Bolt
	*12	0.218	720	—	—	16.4	17.4	13.4	16.3	—	—	—	—
	12	0.375	720	11.2	16.7	—	—	9.4	16.3	—	—	—	—
	12	0.500	1440	21.6	27.2	—	—	16.0	25.4	13.6	23.2	14.0	17.0
	*16	0.260	720	—	—	23.0	16.9	19.1	15.9	—	—	—	—
	16	0.375	720	17.5	16.2	—	—	—	—	—	—	—	—
	16	0.500	1170	22.6	20.4	—	—	20.0	19.6	14.6	19.8	14.9	12.9
X42	16	0.500	1440	27.9	25.2	—	—	24.6	23.5	17.9	23.0	18.3	15.9
	*20	0.313	720	—	—	23.4	18.4	20.1	17.5	—	—	—	—
	20	0.375	720	18.0	17.9	—	—	16.7	17.9	—	—	14.1	11.6
	20	0.500	1170	26.2	25.7	—	—	23.8	25.5	19.6	25.3	19.8	18.4
	20	0.500	1440	—	—	—	—	—	—	—	—	24.6	22.7
	*24	0.366	720	—	—	29.7	17.8	26.3	17.0	—	—	—	—
X42	24	0.375	720	28.2	17.2	—	—	24.9	17.0	—	—	19.7	10.0
	24	0.562	1170	34.1	23.5	—	—	32.5	22.8	23.9	22.7	24.5	15.9

*Data furnished from calculations for the ASA B16 Flange Committee. For these values "h" is full hub length minus 15/16 in.

NOTES:

The dimension "h" for other flanges is taken as the full hub length minus ¾ in.

All wall thicknesses other than those with asterisk based on minimum $t = \frac{PD}{2S}$ using: S = 21,000 psi for Grade B pipe and 25,200 for API Std. 5LX, Grade X42 pipe.

All flange stresses except those for O-Ring Groove are calculated using Section VIII, Appendix II of ASME Boiler and Pressure Vessel Code. Stresses for O-Ring Groove flanges follow the approach by D. B. Rossheim (slightly modified) shown in Taylor Forge Engineering Department Bulletin No. 45.

valves, check valves, pumps, scraper trap closures, etc., which are now installed in the modern pump station.

Second, how about vibration or mechanical misalignment or thermal stresses?

Vibration, mechanical or thermal stresses are probably less serious in lighter weight flanges with O-rings than the heavier standard flanges that transmit these stresses more severely to the lighter weight piping system.

Third, how about ease of replacement?

This shouldn't be any more difficult than replacing a flat gasket.

Fourth, how about sand or other foreign material affecting the tightness of the seal?

Since the sealing part of the O-ring is against its outer edge, we see no problem while it is in service. For replacement, a groove in the flange might be a little more difficult to clean than a raised face. A plate system would not.

Fifth, how about solubility of the O-ring in the product used?

Satisfactory materials are available that will avoid solubility in the liquids handled and aging of the ring.

Sixth, how about excessive bolt tightening?

Excessive bolt tightening is a matter of field control. We suggest using wrenches without extension, which have a limited-length handle.

Admittedly, there are some problems to solve in designing a flange properly to use an O-ring. We recognize that the machining of the flange face and the groove itself can present some problems. These can be solved only by proper design and service experience. They do not appear to present any difficult or expensive obstacles. It is certainly not desirable to promiscuously assign higher ratings to flanges. Each case should be considered separately. The O-ring approach has merit, however, and deserves consideration for this service.

How much do we save by using this method? Fig. 6 shows typical savings for a pair of flanges if ASA 300 flanges are used in place of ASA 600 flanges. Costs shown are factory costs for a pair of flanges plus bolts.

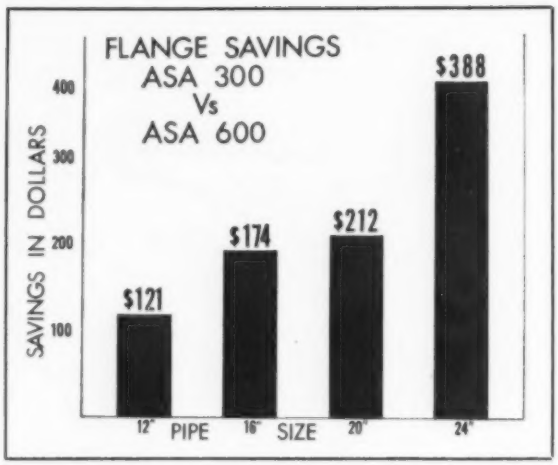

FIG. 6

Acknowledgment. This Graphic Engineering Digest was prepared from a paper presented before American Society of Mechanical Engineers, Petroleum Mechanical Conference, Denver, Colorado, 1958.

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2. E. C. Schuster and V. L. Rupe, "Getting the Most From Your Flange Dollar While Using O-Rings" *Pipe Line Industry*, October 1955.
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GRAPHIC ENGINEERING DIGEST

Cost of Service Approach to Pipeline Economics

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"WILL IT PAY?" This is the question uppermost in the minds of business men considering investment of capital. Phrased differently this means will the company recover its investment in a reasonable time? This recovery is accomplished by producing a product or a service that can be sold at sufficient income to offset operating expenses, taxes, financing charges, and yield a profit.

We will skip price determination in the sense of marketing and selling. The price determination used here will be on the basis of a *cost of service*.

This cost of service may be used to determine which of several ways of performing the service is the most economical as well as which of the ways will enable the company to most advantageously recover its investment.

What Goes Into Cost of Service?

The actual format used to present a study of the cost of service. Fig. 1 and 2 are used by our company. Fig. 1 covers plant type (compressor stations, etc.) studies. Fig. 2 covers pipeline studies. Once this *cost of service* has been determined, it can be used to determine which of several methods is the most economical.

In the preparation of an economic study, an estimate of the cost of equipment and material installed is the first information determined. This cost not only includes equipment, material, and labor of installation as direct costs — it includes other costs some of which have been developed as a percentage of the direct costs. These items are: (1) Other field costs, (2) contractor's fees, (3) overhead, and (4) contingency.

Other field costs. The contractor's fee is straightforward and determined by his bid in response to the scope of the work offered him. But "other field costs" include indirect items such as those listed in Fig. 3.

General overhead costs. These costs are incurred by the company during the construction of a project. They include

FIG. 1. Example of Cost of Service Study.

A. Capital investment (CI)

Equipment installed		$
Other field cost		$
Contractors fee		$
Total direct costs		$
Overhead 5%		$
Contingency 5%		$
Total capital investment		$

B. Annual expenses

Operation & maintenance			
Manning _____$/Year/Man		$	/Yr.
Fuel _____¢/MCF		$	/Yr.
Power _____¢/kw		$	/Yr.
Water _____¢/M gal.		$	/Yr.
Maintenance _____% of CI		$	/Yr.
Misc. & other costs		$	/Yr.
General & adm. _____% of O & M		$	/Yr.
Fixed expenses			
Depreciation	%		
Interest	%		
Taxes	%		
Return	%		
Federal Taxes	%		
Total	% of CI	$	/Yr.
Total annual expenses		$	/Yr.

C. Cost of service

$$\text{Cost of service/unit} = \frac{\text{Total annual expenses}}{\text{Total units handled annually}}$$

that portion of the company's home office expenses dedicated to construction work. A representative list of the items is shown in Fig. 4.

Contingency provision is generally taken at five percent. It will vary according to the length of time required for the completion of a project. Too, a higher contingency is provided for projects of a nature that are foreign to a company's usual projects. The contingency should be high enough to provide for unforseen expenditures. Generally, the contingency provides a pad in the estimate, which will be used primarily for increased material and labor prices that occur during construction of the project.

FIG. 3. Other Field Costs.

A. Items included in "other field cost" provision

1. Camp and commissary
2. Construction superintendence
3. Field engineering and inspection
4. Field office expense
   a. Communications
   b. Medical
   c. Office and clerical
   d. Warehouse
5. Other general costs
   a. Indirect labor
   b. Small tools
   c. Scrap
   d. General clean-up
   e. Painting equipment
   f. Preliminary operations and tests
6. Temporary structures and facilities
7. Allocated general field office
8. Right-of-way department expense
9. Undistributed material
10. Payroll insurance
11. Payroll taxes

B. "Other field cost" as % of direct cost

1. Pipelines	3%
2. Gathering systems	8%
3. Compressor stations	5%
4. Treating and Dehydration plants	3%
5. Gasoline plants	4%
6. General structures and communications	6%
7. Meter stations	2%
8. River crossings	1%
9. Leasehold and gas wells	4%
Average	4%

FIG. 2. Pipeline Project Analysis.

Form 7-169R (8-58) Sheet No._____ Date_____ By_____

PROJECT CASE_____ FLOW SHEET_____

M³ of per day

Estimated Cost of Required Facilities	Quantity		Unit Cost		Total Cost
PIPELINES	Mi.	$	/Mi.	$	
	Mi.		/Mi.		
	Mi.		/Mi.		
	Mi.		/Mi.		
	Mi.		/Mi.		
Total Direct Cost Pipelines				$	
RIVER CROSSINGS				$	
COMPRESSION	hp		/hp	$	
	hp		/hp		
	hp		/hp		
	hp		/hp		
	hp		/hp		
	hp		/hp		
	hp		/hp		
	hp		/hp		
	hp		/hp		
Total Direct Cost—Compression				$	
COMMUNICATIONS				$	
METER STATIONS				$	
GENERAL STRUCTURES & EQUIPMENT				$	
Total Direct Cost				$	
Plus: General Overhead @ 5%				$	
Contingency @ 5%					
TOTAL COST				$	

USE

Estimated Cost of Service @ ___% Load Factor & 6½% Return

	Quantity		Unit Cost		First Year		5-yr Avg
Transmission Line Expenses, Operating & Maintenance	Mi.	$	/Mi.	$		$	
Compressor Station Expenses, Operating & Maintenance — Reciprocating	hp		/hp				
— Electric	hp		/hp				
Compressor Station Expenses, Fuel	Mcf		¢/Mcf				
, Purchased Power	hp		/hp				
Adm. & General and Division Office Expenses							
Fixed Charges to Include: Depreciation, Taxes,	First Year—		%				
Interest and Return on Investment	5 Yr Avg.—		%				
TOTAL—EXCLUSIVE OF COST OF GAS				$		$	
COST PER Mcf (Mcf/Yr)					¢		¢

Making Capital Cost Estimates

El Paso Natural uses three different types of capital cost estimates:

Class A or initial estimate. This is in the nature of a horseback type estimate and prepared with a minimum of information in regard to facilities. The costs are determined from estimating curves similar to the one shown in Fig. 5, which illustrates the cost of complete compressor stations, including off-site facilities. The curve is based on past experience, in this case representative of 1956 costs. To bring the information up to date it will be necessary to apply a cost index. Several cost indices are published.

Class B or preliminary estimate. This is prepared when additional design information is available. Cost of major equipment items are investigated (such as compressor units, housing, etc.). Major components for these estimates are derived from curves, installation factor methods, or tabular information.

Class C or final estimate. This is the detailed bill of material estimate, which is prepared after all design questions have been settled and actual quotations received for equipment. It requires a considerable length of time as each bill of material is priced and installation labor is determined by manhour estimates of the factor method. It requires on-the-spot surveys of plant sites, etc.

FIG. 4. Breakdown of General Overhead Costs.

Description	As percentage of direct cost
Engineering	1.35%
Inspection	0.15%
Legal services	0.02%
Auditing services and expenses	0.10%
Preliminary survey and investigation	0.04%
Executive department	0.01%
Insurance and taxes	0.03%
General construction accounting department	0.35%
Purchasing and traffic department	0.10%
Interest during construction	2.85%
TOTAL	5.00%

How the estimates are used. During initial planning for capital expenditures, Class A estimates suffice. As several possible ways of accomplishing the task are determined, those that appear most economical should be investigated further, and more accurate estimates of the Class B and Class C type should be applied.

Annual Expenses

Annual expenses essentially are the costs of owning and operating the equipment that has been installed (See Fig. 1. for a breakdown.)

Operation and maintenance. In the preparation of an economic study, the facilities that are being installed will require operation and maintenance. The items that make up this expense should be determined and proper allowances made for them.

Manning should be determined in the form of either additional men required or a proportionate share of existing manning that is dedicated to the new installation. Also estimate the dependability of the equipment to make allowance for maintenance.

Raw materials. The cost of fuel, water, and power should be determined.

Maintenance. Unit costs for operation and maintenance expenses can be developed from past experience for any company. One of the most important factors in determining this cost is to completely investigate unit costs that go in to this category. There are different practices within the companies with regard to scheduled maintenance, manning requirements as dictated within various states, policies with regard to oil changing in engines, etc.

General and Administrative Expense

This expense is expressed as a percentage of the operation and maintenance. (See Fig. 6.) This percentage is developed by the following relation:

$$\text{Percent general \& administrative} = \frac{\text{Total Company general \& administrative expense}}{\text{Total company operation \& maintenance expense}}$$

FIG. 6. General and Administrative Expenses.

Salaries of general officers and executives
General office salaries
Expenses of general officers
Expenses of general office employees
General office supplies and expenses
Special services
Special legal services
Regulatory commission expenses
Insurance premiums
Injuries and damages
Employees welfare
Pensions
Miscellaneous general expenses
    Fees of trustees, registrar, transfer agent, stockholder's expenses
    Association dues and memberships
    Sundry
Maintenance of general structures and improvements
Maintenance of general office equipment supplies and expenses
Rents

Multiplication of the study operation and maintenance by this percent so obtained will provide allowance for this expense.

It is important to maintain consistency in the items contained in the operation and maintenance expenses. They should be consistent with those used in determining the total operation and maintenance of the company.

Fixed Expense

Each of these items can be expressed as a percentage of the capital investment. The percentages can be expressed as those which would occur as an average for any period over the life of the project. By developing these percentages, we have found a considerable time-saving element in making annual cost studies for various projects.

Depreciation. As used by El Paso, depreciation is the process of charging reserve for depreciation as an annual expense item an amount of money that accumulated over a period of years, is equivalent to the initial cost of the facility, less salvage value. The number of years over which reserve is to be accumulated has been governed by the factors of gas supply and physical life of the installed facilities.

The effect that gas supply life has on depreciation is appreciable and this same thought could be expressed, "will the raw materials on which the facilities are dependent be in sufficient supply for a long enough period of time so that

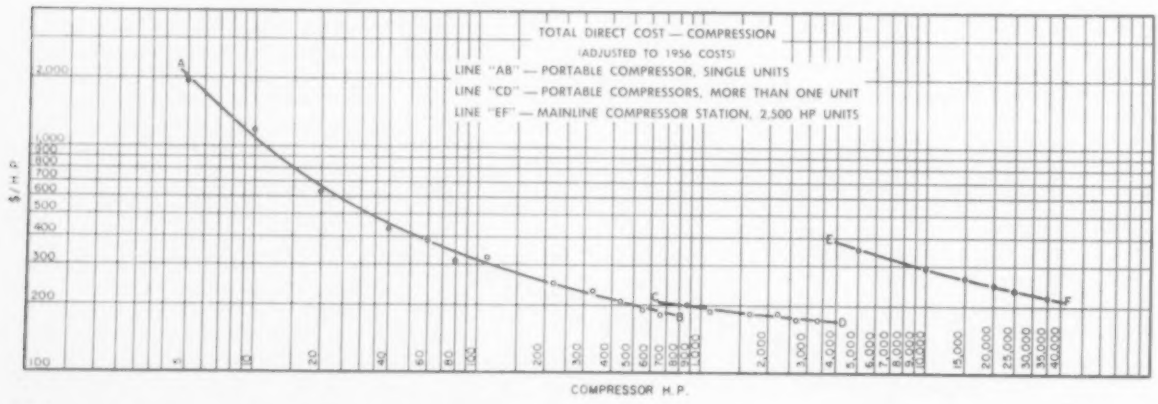

TOTAL DIRECT COST — COMPRESSION
(ADJUSTED TO 1956 COSTS)
LINE "AB" — PORTABLE COMPRESSOR, SINGLE UNITS
LINE "CD" — PORTABLE COMPRESSORS, MORE THAN ONE UNIT
LINE "EF" — MAINLINE COMPRESSOR STATION, 2,500 HP UNITS
$/H.P.
COMPRESSOR H.P.

FIG. 5. Estimating sheet for compressor installations.

the cost of producing the product will not be distorted by a high annual depreciation cost?"

One of the most common depreciation schedules is the straight line method, which recovers a fixed amount each year and is determined by:

$$\text{Depreciation/year as \% of capital investment} = \frac{100\% - \text{salvage value as \%}}{\text{Depreciation life in years}}$$

There are other methods of depreciation such as the Declining Balance and Sum of the Digits. These are used to provide high depreciation rates in the early years for rapid recovery of the capital investment. An illustration of the comparison of four methods of depreciation is shown in Fig. 7. Note that the total accumulated depreciation reserve is the same for each method, and therefore, the choice of methods is immaterial when considering the average over the life of the project.

Interest. This is an expense item that should be charged, in many cases, even if there are no borrowed funds involved for the project. These non-borrowed funds could be invested instead of being used for the project.

Computation of interest expense depends on the following factors: (1) **Term of the loan** or the number of years over which re-payment is to be made. (2) **Manner of re-payment** — the number of payments — annually or semi-annually. (3) **Interest rate.** (4) **The debt-equity ratio,** which is the ratio of borrowed money (debt) to the amount provided from other company sources (equity).

Fig. 8 illustrates interest computation. The key to the preparation of this chart is Column B and is the division of the 75 percent into the number of payments to be made. Note that a slight adjustment is required for the 28th payment.

Taxes other than federal income tax. This includes payroll taxes, franchise taxes, ad valorem taxes levied by the state, county, and school districts within which facilities have been installed. Generally, 1 to 1½ percent of the capital investment will cover these items adequately.

Return on investment. In the controlled industries, the return or profit is specified by the government at approximately 6½ percent of the rate base. This percentage includes the interest on borrowed funds. Simplified, by taking 6½ percent of the average annual investment [(capital investment — salvage value)] × 50 percent and subtracting the interest from this answer, the return to the company is determined. This may be expressed as a percent of capital investment. This profit is the residue available to the company after payment of federal income tax and represents 48 percent of the total profit when income taxes are 52 percent of the profit.

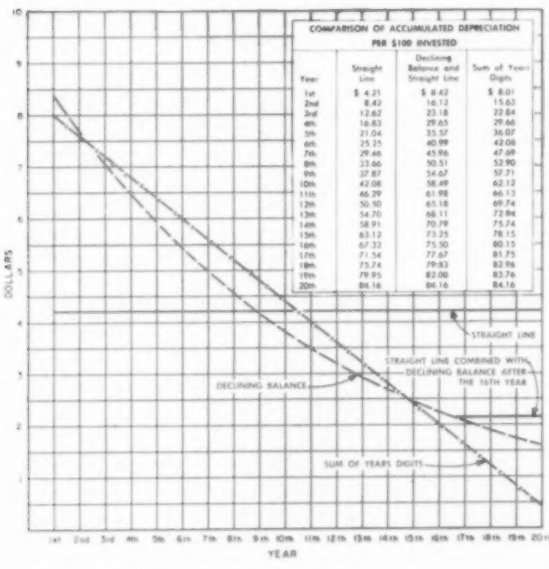


FIG. 7. Depreciation per $100 invested, 20-year life with 15.84 percent salvage value.

FIG. 8. Computation of Fixed Charges for Economic Studies. Interest

15 year amortizable debt and a ¾-¼ long term debt-equity ratio.

A. At end of:	B. Interest-bearing principal remaining	C. Average annual interest-bearing principal
½ year	75.000	
1 year	75.000	75.0000
1½ years	75.000	
2 years	72.321	73.6605
2½ years	69.642	
3 years	66.963	68.3025
3½ years	64.284	
4 years	61.605	62.9445
4½ years	58.926	
5 years	56.247	57.5865
5½ years	53.568	
6 years	50.889	52.2285
6½ years	48.210	
7 years	45.531	46.8705
7½ years	42.852	
8 years	40.173	41.5125
8½ years	37.494	
9 years	34.815	36.1545
9½ years	32.136	
10 years	29.457	30.7965
10½ years	26.778	
11 years	24.099	25.4385
11½ years	21.420	
12 years	18.741	20.0805
12½ years	16.062	
13 years	13.383	14.7225
13½ years	10.704	
14 years	8.025	9.3645
14½ years	5.346	
15 years	2.667	4.0065

Above based on 28 payments beginning 18 months after issuance, the first 27 equal payments of 2.679 and the 28th of 2.667.

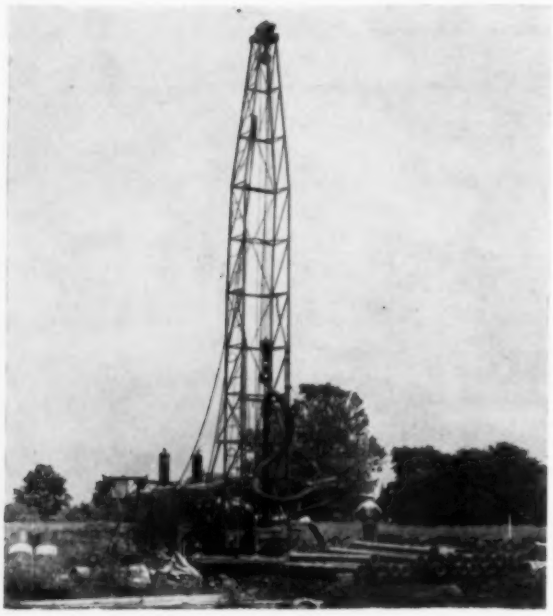
Note: 1. To get interest for any given year, multiply the proper average annual interest bearing principal from Column C by annual interest rate. (as decimal).

2. To express interest as percent of capital investment use Note 1 percentage as decimal.

Federal income tax. For corporations with net income in excess of $25,000, federal income tax is 52 percent of total profit. Since, by preceding definition, return represents 48 percent of profit, the calculation for federal income tax is 52 ÷ 48 = 1.0833. This factor times the return (exclusive of interest) will result in a federal income tax to be included in the cost of service. This may be expressed as a percent of capital investment by multiplying the return as a percentage of capital investment by 1.0833.

Conclusion. The preparation of accurate *cost of service* studies depends to a large degree on the experimental background data accumulated by the company. In addition, there is the very important common sense factor that must be applied by experienced engineers.

The author wishes to acknowledge the assistance of R. B. Herr, G. B. Heflin, C. E. McIntyre, and Virgil Cowart in the preparation of this paper. ★ ★ ★



1. After a suitable rock formation for LPG storage was found, first step was to drill a main shaft 4 ft in diam to the top of the formation and case it with 42-in. pipe.

2. Workmen then mine out a small room at the bottom of the shaft by hand, after which heavier mining equipment is utilized. Here part of an air-powered scoop is being lowered.

An Underground Storage Pool Takes Form

Out of solid rock men and machines are carving huge vaults for storage of 18,900,000 gal of LPGas by Texas Eastern

HARDROCK MINERS are burrowing deep underground a few miles south of Middletown hollowing out three huge caverns in hard grey shale that will become Ohio's largest underground storage pool for liquefied petroleum gases.

The storage facility, known as Todhunter Terminal, is being constructed for Texas Eastern Transmission Corporation, Shreveport, Louisiana. When the storage terminal is placed in service next fall, it will have a capacity of some 18,900,000 gal with provisions for adding capacity as the need arises.

The Todhunter Terminal will be used to receive, store, and distribute liquefied petroleum gas, more commonly known as LPGas or bottled gas, by truck and rail transport over a wide range of states from Michigan to New England, according to Millard K. Neptune, senior vice president of Texas Eastern in charge of the company's Little Big Inch (petroleum products pipeline) division. The product will be shipped to the storage terminal from the Gulf Coast via Texas Eastern's Little Big Inch petroleum products pipeline.

The storage cavern at Todhunter Terminal will be the largest in the state of Ohio when it is completed. At the present time, there is only one other underground storage facility for LPGas in Ohio, that owned by Standard Oil Company (Ohio) in Allen County near Lima. They have two caverns there storing propane that have a total capacity of 2,560,000 gal.

The caverns at Middletown will be similar to underground storage facilities for LPG's already in use at Crossville, Kankakee, Tuscola, and Eola, Illinois; Marcus Hook, Pennsylvania; Siloam, Kentucky; Bayway, New Jersey, and many locations in Texas, Louisiana, Oklahoma, and Mississippi.

Underground caverns are considered ideal facilities for storage of liquefied petroleum gases both from the standpoint of safety and economy.

Mother Nature Did It First

The idea of storing petroleum products underground is not new. "Mother Nature" has been doing it for millions of years. Every crude oil or natural gas producing field is in reality an underground storage pool where nature has been holding these products in "storage" until man needed them.

LPGas underground storage caverns are simply man-made caverns under the surface of the earth where butane or propane, or mixtures of the two, are injected in their liquid state under pressure to be held until needed. Pressure of the gases in these caverns is less than that required to store them above ground in steel pressure tanks.

In addition to the underground storage facilities, Texas Eastern has also constructed and placed in operation, a complete fractionating and dehydration plant at the Todhunter Terminal. This plant is used to clean the LPGas of all impurities and water before it is delivered to customers. The terminal also has complete truck loading racks and rail facilities to load the products into rail tank cars.

Steps in Cavern Construction

Construction of storage caverns such as those at Todhunter Terminal is done in several steps. The company first sends testing crews into an area under consideration where they drill small diameter holes several hundred feet

into the ground to determine the type of rock formations present. If these formations are considered satisfactory for LPG storage, plans are then made to construct the storage caverns.

Texas Eastern purchased a site of approximately 89 acres for the storage facility. The storage cavern when completed will be located entirely under the property purchased by the company. There will also be space to construct a number of other LPGas storage caverns under the property.

When the actual work began, a large hole more than 4 ft in diameter was drilled in the ground down to the level of the rock formation to be used and then cased with a 42-in. steel pipe. Workmen went down to the bottom of the hole and mined out a small room.

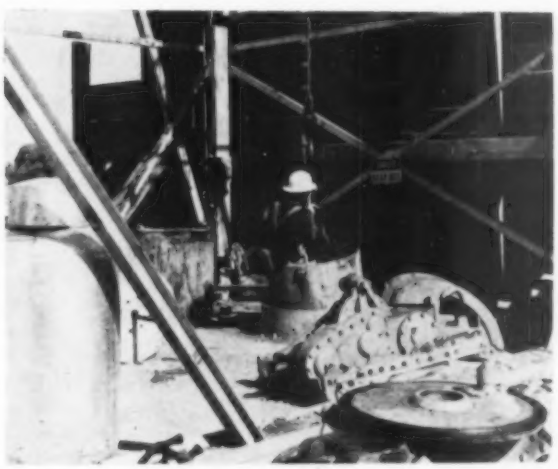
A large high-lift bulldozer was completely taken apart on the surface, lowered piece by piece to the bottom of the hole and reassembled. Using this and specialized mining tools, large corridors 15 ft wide and 20 ft high are hollowed out in the rock formation. Workmen remove one-third of the stone and leave two-thirds in place to make sure there will be no caving of the roof.

The gases in liquid form are pumped down into the cavern where they are held until needed. They are then pumped to the surface, cleaned of all impurities, placed into above-ground

3. Some 350 ft below ground hardrock miners reassemble the air-powered scoop before putting it into operation clearing out rooms that will form a cavern for the LPGas.

4. Another piece of heavy equipment is going underground . . . a bulldozer motor is lowered into the hole.

5. Miners reassemble the bulldozer underground and use it and other specialized mining tools to hollow out in the rock formation large corridors 15 ft wide and 20 ft high.



6. A miner is lowered into the hole for the dark journey 350 ft to the site of the mining operation. Four workmen can be lowered in the bucket at the same time.

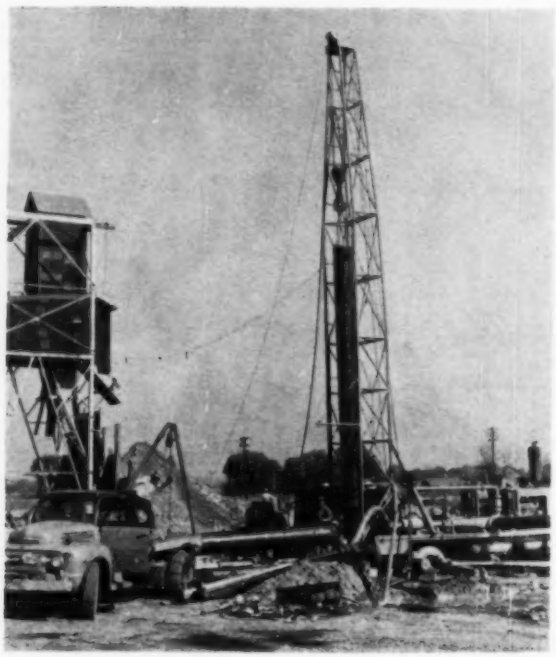
tanks from which they will be transported to distributors.

Underground Storage Growing

Recent studies of storage facilities made by the National Petroleum Council show that use of the underground cavern is continually increasing. At the end of 1957, it was estimated that volumes approaching 1.5 billion gal of LPG's were being stored underground. Continually increasing use and expansion of underground storage facilities is expected to raise this level to the 2.5 billion gal mark within the next few years.

Texas Eastern is one of the nation's largest pipeline companies with more than 7700 miles of pipeline in service. The company transports natural gas from Gulf Coast producing fields through a 6000 plus mile pipeline network to markets in the East. Through a 1700-mile products pipeline network, the company transports the full range of refined petroleum products including LPGas from Gulf Coast and Mid-Continent refining centers to markets in the Midwest. Soon the company plans to extend its pipeline service to the East Coast for transportation of LPGas into other areas where this fuel is in great demand. ★ ★ ★

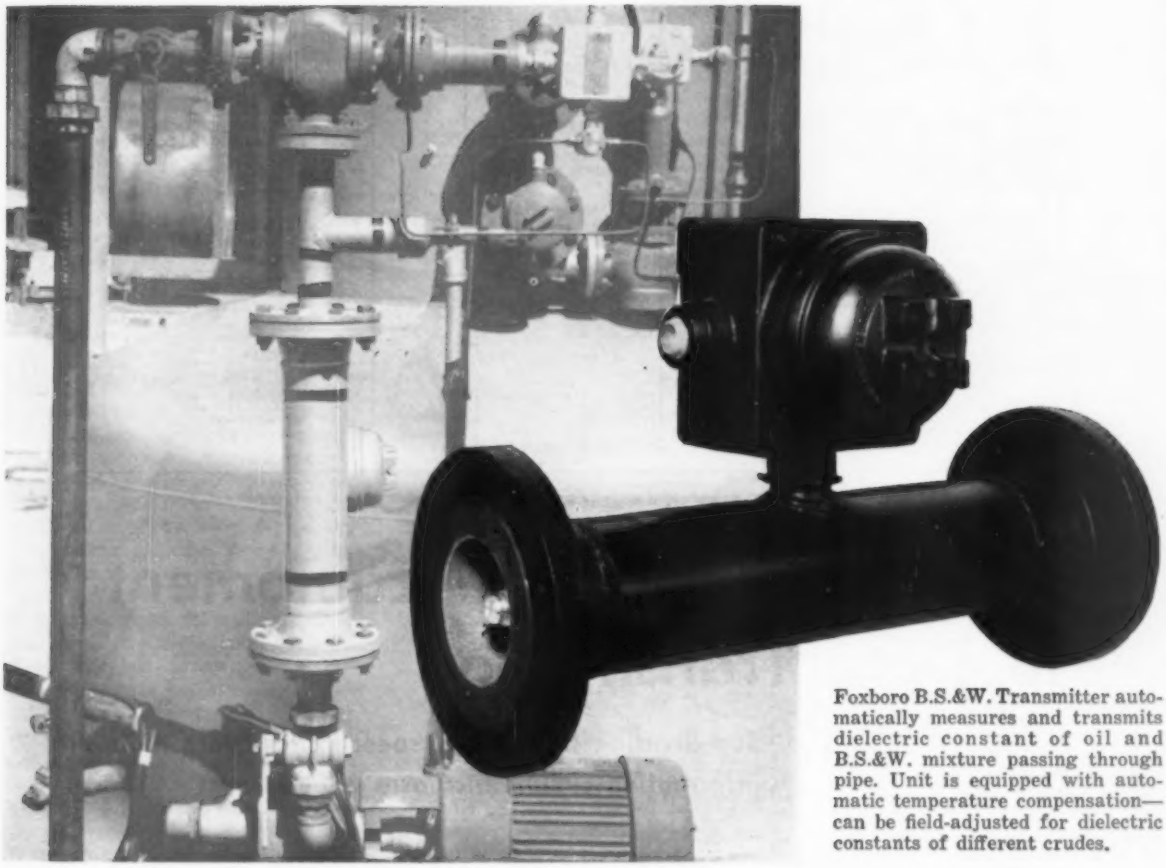
7. With the air scoop shown at the lower right buckets are loaded with mined shale and sent to the surface.



8. Buckets loaded with shale emerge through the cased hole beneath rig at left. At right men are constructing a ventilation hole necessary to provide air to the miners below ground.

9. One of the rooms that will form a portion of the huge cavern, being "carved out" by the diligent work of experienced hard-rock miners.

10. The cavern formation takes shape as successive rooms are completed. Workmen remove one-third of the stone and leave two-thirds in place to make sure there will be no caving of the roof.



Foxboro B.S.&W. Transmitter automatically measures and transmits dielectric constant of oil and B.S.&W. mixture passing through pipe. Unit is equipped with automatic temperature compensation—can be field-adjusted for dielectric constants of different crudes.

unique Foxboro system gives continuous, unattended measurement of B. S. & W.

— *plus records to prove it.*

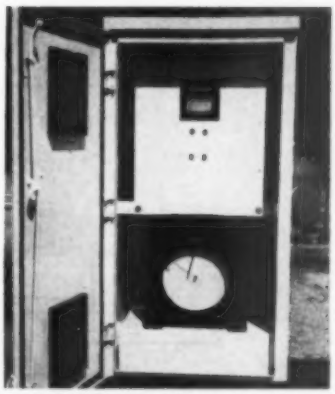
The instant the B.S.&W. content of crude oil exceeds preset percentage you know it, with this unique Foxboro monitoring system.

Here's how. A Foxboro measuring element, installed in the pipeline, continuously measures B.S.&W. content of the crude, in terms of dielectric constant. Changes in dielectric are then transmitted electrically to a Foxboro capacity Dynalog* Recorder.

And that's it. Remedial action can be incorporated by having the Dynalog Recorder equipped with an electric contact for sounding an alarm or operating diversion valves to re-route off-spec oil.

Not only does the Foxboro B.S.&W. System fully meet the specifications of A.P.I. Bulletin 2509A, but also it is the most accurate, automatic, and trouble-free method of policing B.S.&W. available. Ask your nearby Foxboro sales engineer for details. He can tell you about dozens of these systems now at work throughout the world. **The Foxboro Company, 385 Norfolk Street, Foxboro, Mass.**

*Reg. U. S. Pat. Off.



Capacity Dynalog Recorder (lower instrument) receives measurement from B.S.&W. Transmitter, records it, and initiates alarms or re-routing of oil flow.

FOXBORO instrumentation

REG. U.S. PAT. OFF.

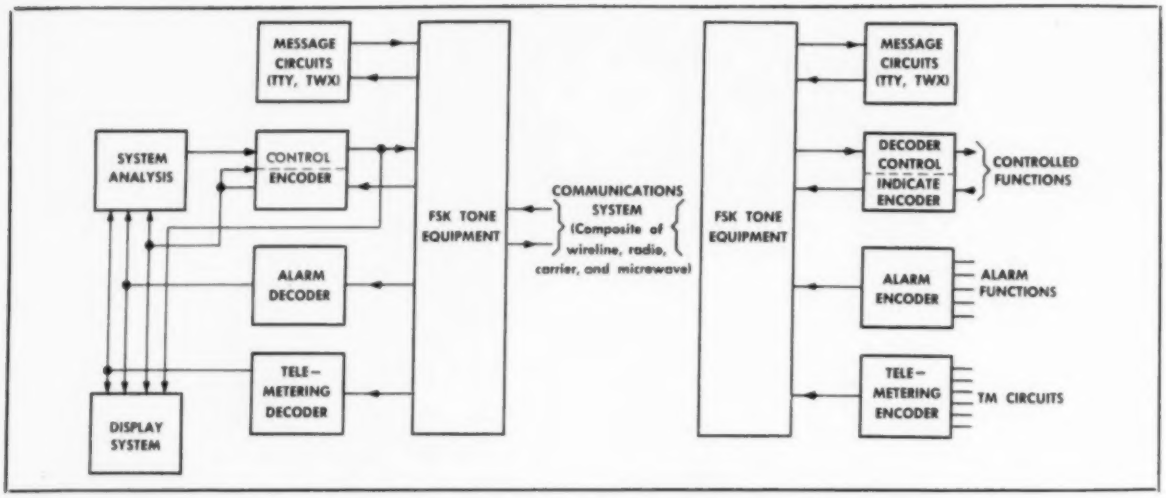


FIG. 1. Functional application of tone equipment to pipeline communications systems.

Application of Tone Equipment to Data Transmission

Sub-dividing the normal speech circuit into multiple information circuits increases effectiveness

Peter R. Braginton
Datatrol Company

IN THE INTERPRETATION of communications as "an exchange of words, letters, and information" the last area is frequently overwhelmed by the other two. Pipeline operations, where "words and letters" may be too slow or too late, place an operational premium on "information" and are among the heaviest users of such communications.

Proper utilization of tone equipment, by sub-dividing the normal speech circuit into adequate multiple information circuits, will greatly increase effectiveness. Specifically the areas of improvement are increased traffic density, higher traffic reliability, greater system flexibility, and lower overall cost.

Four types of circuits. The four general types of information circuits can be classed as (1) message, (2) control, (3) alarm, and (4) telemetering circuits. They are grouped within a communications system as shown in Fig. 1.

Message circuits include those for telegraph, teletype, and facsimile. Control circuits perform control function generation, check performance, and indication. Alarm circuits accommodate generation and indication of alarm conditions. Telemetering circuits handle information on the measurement of quantitative variables.

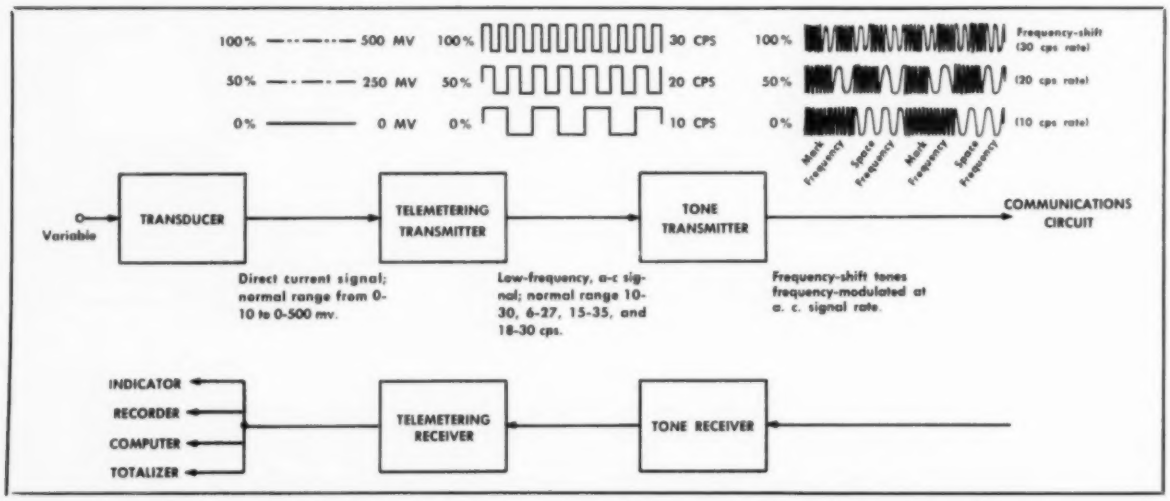


FIG. 2. Continuous telemetering system. Maximum present data rate 35 cps. Future data rate 300 to 2000 cps.

Nature of signals. Before investigating the types and methods of operation of available tone equipment, the nature of signals to be conveyed should be reviewed. The signals will be handled as electrical pulses and will almost always exist as either square wave or sine wave pulses.

Data rate, the pulse repetition rate or keying speed, primarily determines the operating characteristics of the tone equipment. Widest range of data rates is found in telemetering, and because this range more than covers those rates found in the other three circuits, it will be considered first.

Basic Types of Telemetering

Telemetering in the pipeline industry is of three basic types. In a *continuous telemetering system* we are continuously reading, transmitting, recording, and indicating the level of individual measured variables such as pressure, temperature, density, rate of flow, specific gravity, etc. In a *continuous display telemetering system* we periodically read, transmit, and record the individual levels while continually displaying the last correct reading. In a *time-multiplexed telemetering system* the reading, transmitting, recording, and indicating of the multiple levels is done in a series of signals divided in time and programmed in sequence.

Fig. 2, 3, 4, and 5, are block diagrams comparing transmission of the three types. It should be noted that in every case we are dealing with pulses whose rates are characteristic of a specific telemetering system. The continuous telemetering system involves maximum data rates as high as 35 cps, whereas the "non-continuous" systems involve pulse rates as low as 4 cps. In the other three circuits we are dealing with comparable pulses whose rates range from some 100 pps for 250 wpm teletype circuits to essentially zero rates for long-time control circuits. These are summarized in Column 3 of Table 1.

Frequency-Shift Keying

In the frequency-shift keying method of pulse transmission a dual-tone oscillator-receiver circuit is used. Under non-keyed condition, a pulse condition representing "non-information," the oscillator is generating a tone called the "space" tone. When an "information" pulse condition "keys" the transmitter, its oscillator circuit is changed abruptly and a higher frequency tone, the "mark" tone, is generated.

In both pulsing conditions, the tone is applied to the communications circuit through an amplifier and a transmitter band-pass filter. The receiver receives the tone through its band-pass filter and the specific tone frequency is

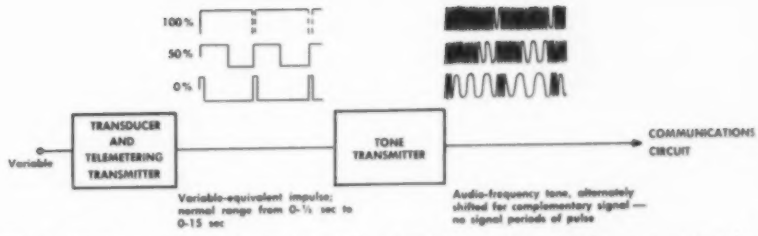


FIG. 3. Continuous display (pulse duration) telemetering system. Maximum present pulse rate 2 cps.

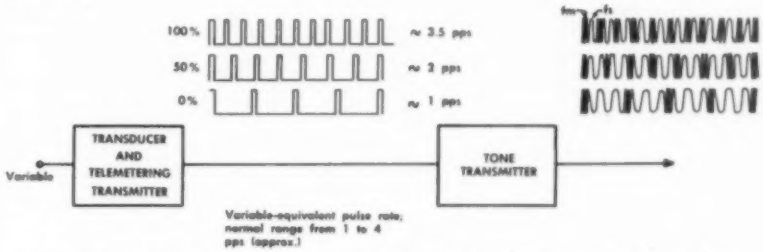


FIG. 4. Continuous display (pulse rate) telemetering system. Maximum present pulse rate 4 cps.

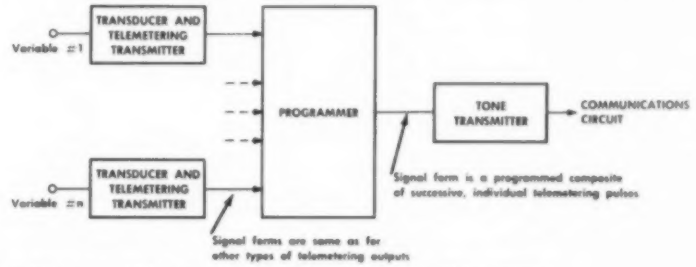

Variable ±1
TRANSDUCER AND TELEMETERING TRANSMITTER
PROGRAMMER
TONE TRANSMITTER
COMMUNICATIONS CIRCUIT
Variable ±n
TRANSDUCER AND TELEMETERING TRANSMITTER
Signal form is a programmed composite of successive, individual telemetering pulses
Signal forms are same as for other types of telemetering outputs

FIG. 5. Programmed telemetering system. Data rates as per other systems.

recognized by the discriminator circuit. This circuit delivers a high-level output signal only from tones of the proper frequency and notes the "mark" or "space" tone by opposite polarities. Other frequencies are rejected by a combination of filter band-pass and discriminator tuning characteristics. An amplifier-output keyer combination delivers a pulsed output corresponding to the input keying of the transmitter. This operation is shown schematically in Fig. 6. Fig. 7 is a photograph of the unit.

The key elements in the transmitter-receiver combination then are the band-pass filters and the discriminator. Our previous discussion of data rates and pulse types now becomes pertinent. When a tone oscillator is keyed by a series of pulses, additional frequencies called sidebands are generated. The amplitude and distribution of these additional frequency components is determined by the nature of the keying pulse and by its pulse rate. A. Mack*

*A. Mack, "Carrier Telegraph Systems," Signal Corps article, February 26, 1951.

TABLE 1. Summary of Information Circuit Requirements.

Type of circuit		Data rate, pps	Tone channel bandwidth required	Tone channel bandwidth available	No information channels/speech channel
Message	Telegraph	15	60 cps	60/100	32/20
	Teletype, 60 wpm	23	100 cps	100/120	13/25
	Teletype, 100 wpm	37	148 cps	150/170	18
	Teletype, 250 wpm	100	400 cps	680	3
	Data processing information	1000	4000 cps	5000	non-audio
Control	Pulse-code keyed	to 20	80	100/120	17/25
	Direct-keyed	10	40	50/120	39/25
Alarm	Pulse-code keyed	to 20	80	100/120	17/25
	Direct keyed	10	40	50/100	39/25
Telemetering	Continuous	to 35	140	150/170	18
	Continuous display	to 4	16	50/100	39/25
	Time multiplex	to 4	16	50/100	39/25

Note: 300-3400 cps audio band-pass (assumed).

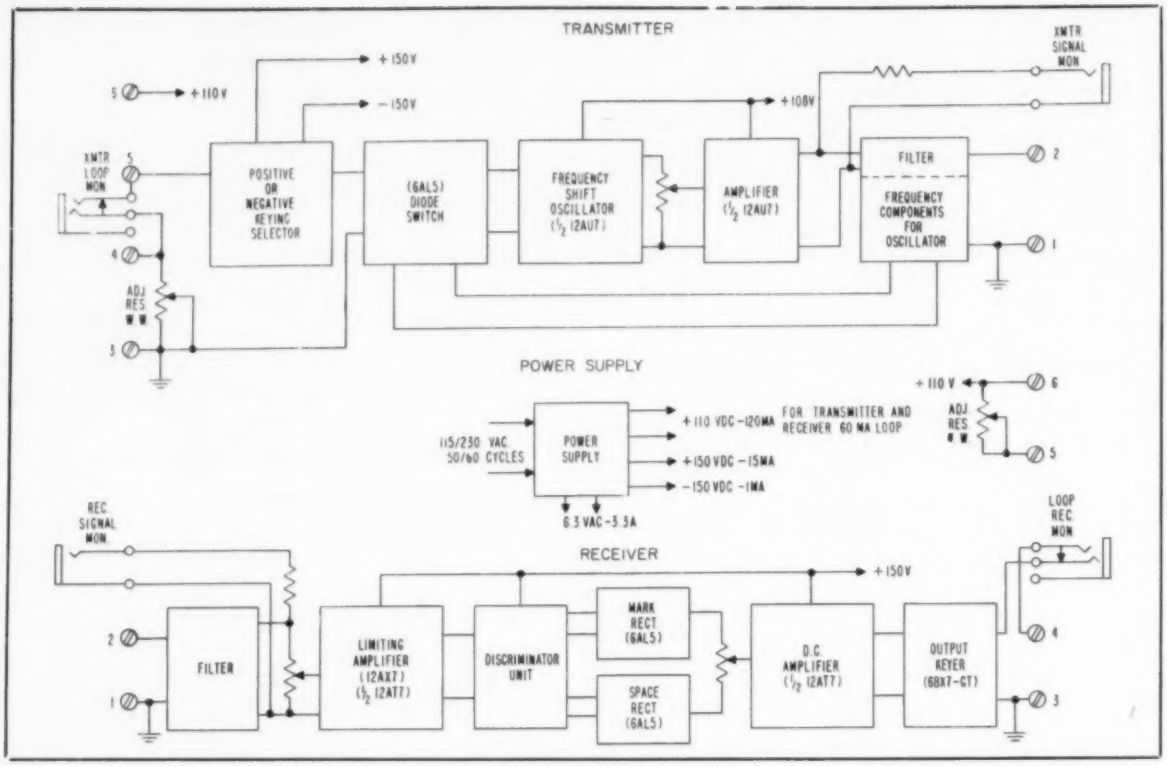


FIG. 6. Block diagram of a frequency-shift keyer transmitter-receiver terminal.

determined that for frequency-shift operation the total frequency shift between space and mark frequencies should be at least twice the keying speed. There must be an adequate guard-band left between adjacent operating frequencies and, for minimum distortion, this should be equal to the keying speed. Thus, for each channel we have the frequency and band-width characteristics shown in Fig. 8.

Another important frequency consideration is that we must minimize harmonic and intermodulation distortion between channels. Standard frequency channels adopted by the communications industry are at discreet center frequencies and spacings and utilize frequency shift increments such that:

(a) No sum or difference frequencies that might be produced by intermodulation distortion fall on the operating points of another channel.

(b) No even-order harmonic of one channel falls on the operating point of another channel.

Additional precautions that may be taken to further minimize such distortion are the use of higher frequency channels, the use of a "guard channel" between tone channels transmitting to and receiving from opposite directions. Where tone channels and voice channels are operated over the same speech

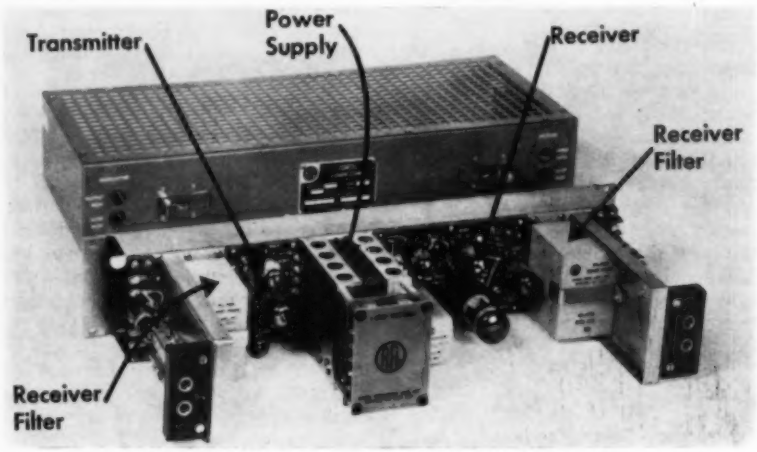


FIG. 7. Frequency-shift transmitter-receiver unit for pipeline information circuit.

circuit (speech-plussed), at least 40 db of filter isolation should be provided between the upper voice cut-off frequency and the next adjacent tone operating frequency.

In addition to determining channel data rate through band-pass characteristics, the transmitter and receiver filter rejection characteristics make possible the use of multiple tones operated in parallel. As many as 39 low-rate channels can be sub-multiplexed into a single voice channel.

Tables 1, 2 and 3 are summaries of information circuit characteristics.

The dual-tone operation of FSK equipment offers inherent adaptability to "self-monitoring" circuits for circuit outage detection, to "self-disabling" circuits for the protection of control circuits, and to "self-detecting" circuits for the initiation of alarm signals. Because either a "Mark" or a "Space" tone is present on a normal FSK circuit, the absence of both tones, easily detected at the receiver limiter stages, can be used to protect simultaneously a control system from noise-initiated functioning and to initiate a "Control Circuit Outage Alarm" signal.

Other Suitability Considerations

In addition to detailing information circuit applications and considering frequency-shift keyed tone operation as applied to these circuits, there are other considerations in deciding operational suitability. Equipment used must provide optimum economy of circuit utilization, must be compatible with both existing equipment and future system operation, and, with automatic operation entrusted to it, must be reliable.

Table 1 indicates some inconsistencies in required data rates vs commercially available FSK tone equipment bandwidths. It must be noted, however, that a wide range of combinations of data rates and functions can be accommodated through the use of commercial items and their use usually will be most economical. Circuit economy requires no more bandwidth assigned to a function than needed for its data rate; maximum circuit reliability will be degraded if less than that bandwidth is assigned. Thus, careful choice of equipment, bandwidth, and operating frequencies must be made.

Equipment compatibility with currently-operated equipment and with future plans is mandatory. Such electrical characteristics as impedances, input and output power levels, frequency assignments of spacing and shift, power source and power requirements, and compatibility with other communications equipment and media must be considered. Physical characteristics such as size, type of mounting, etc., must coincide with existing facilities. Ease of expansion must be weighed against projected need for expansion. Most FSK tone equipment designed for pipeline operation provides economical initial installation of both high and low density stations while retaining the capability of the single or dual channel expansion typical of pipeline operations. The use of modular, plug-in frequency-determining and band-pass units will greatly facilitate economical expansion, conversion, and maintenance programs.

Because of their simplicity and low cost, tone channels working in conjunction with relays and stepping switches can provide inexpensive low-density control functions. A single FSK duplex channel can provide an ON-OFF function control and indicate channel; a dual channel can provide a RAISE-OFF-LOWER function control and indicate channel.

Another area of compatibility to be considered is that of terminal equipment required in conjunction with the FSK equipment. It must easily key or be keyed by switches, relays, teletypewriters, and telemetering terminals with an absolute minimum of additional intermediate equipment required.

Reliable operation of information circuits is mandatory. Components and circuits should be as completely self-contained as possible with a minimum dependence on common equipment groups whose failure could disable large channel groups. Conservative design and operation are assumed inherent in commercial equipment for pipeline equipment; however, the equipment still must be designed with ease of maintenance, preventive and emergency, in mind. ★ ★ ★

TABLE 2. Standard Channel Frequencies.

170 cycle spacing ± 42.5 frequency shift		
Channel no.	Center frequency	Maximum dot cycle rate
1	425	40
2	595	40
3	765	40
4	935	40
5	1105	40
6	1275	40
7	1445	40
8	1615	40
9	1785	40
10	1955	40
11	2175	40
12	2295	40
13	2465	40
14	2635	40
15	2805	40
16	2975	40
17	3145	40
18	3315	40

340 cycle spacing ± 85 frequency shift		
1	1615	75
2	1955	75
3	2295	75
4	2635	75
5	2975	75
6	3315	75

120 cycle spacing ± 30 cps frequency shift		
Channel no.	Center frequency	Maximum dot cycle rate
1	420	30
2	540	30
3	660	30
4	780	30
5	900	30
6	1020	30
7	1140	30
8	1260	30
9	1380	30
10	1500	30
11	1620	30
12	1740	30
13	1860	30
14	1980	30
15	2100	30
16	2220	30
17	2340	30
18	2460	30
19	2580	30
20	2700	30
21	2820	30
22	2940	30
23	3060	30
24	3180	30
25	3300	30

680 cycle spacing ± 120 frequency shift		
1	1615	100
2	2295	100
3	2975	100

TABLE 3. Information Circuit Availability on "Speech-Plus" Operation. (2000 cps voice cut-off in 300-3400 cps audio band-pass)

Data rate, cps	Information circuits
10	11
20	11
30	10
37	7
75	3
100	1

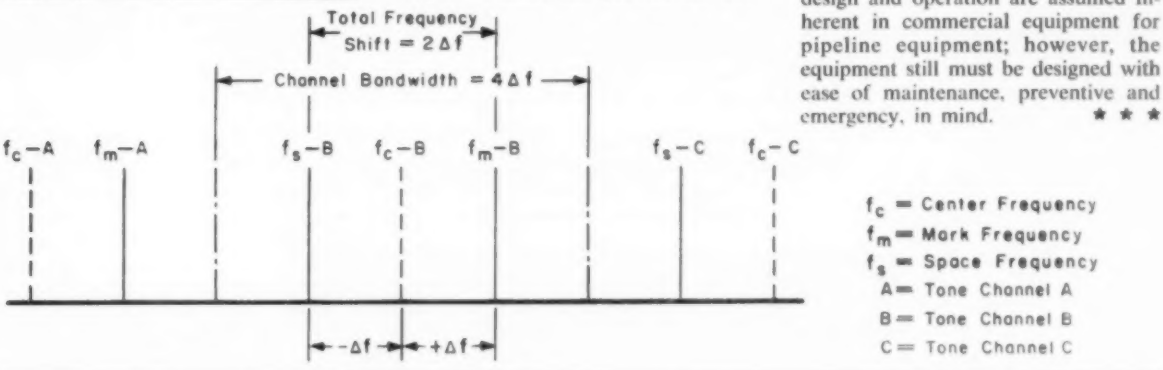


FIG. 8. Frequency and base-band characteristics of frequency-shift tone equipment.

New Barber-Greene 7′ Wheel Ditcher crowds through rugged caliche in Texas—at speeds many times greater than ladder ditchers or back hoes working in the area. Write for details.

NEW 7-FOOT WHEEL DITCHER

digs more ditch . . . deeper ditch than any machine in its size range

Barber-Greene's new 7′ wheel ditcher offers more ditch for the money than ever before. It digs deeper than any wheel ditcher in its size and price range.

Check these advantages:

Advanced design. Greater maneuverability—smaller, more compact than other wheel ditchers digging to 7′. The only wheel ditcher available with point of balance at center of tracks.

Costs less to operate—exclusive Barber-Greene design advantages add up to more ditch per day with less maintenance . . . less down time . . . less wear.

Full range of crowding speeds—exclusive Barber-Greene Hydra-Crowd provides infinite range of crowding speeds . . . permits top digging capacity in all conditions.

Easier to operate—full hydraulic controls within easy reach means less operator fatigue . . . easiest steering . . . greater accuracy.

All-hydraulic spoil conveyor—10′ variable-speed conveyor loads directly into trucks . . . handles spoil at speeds to 640 fpm. Folds to 8′. Rubber impact rollers reduce belt wear, eliminate material build-up beneath belt.

New, compact size—only 26′5″ long, 8′6″ high in operating position. 7′ wide across tracks.

59-10-D

These are just the high spots. Ask for complete details.

Barber-Greene BG

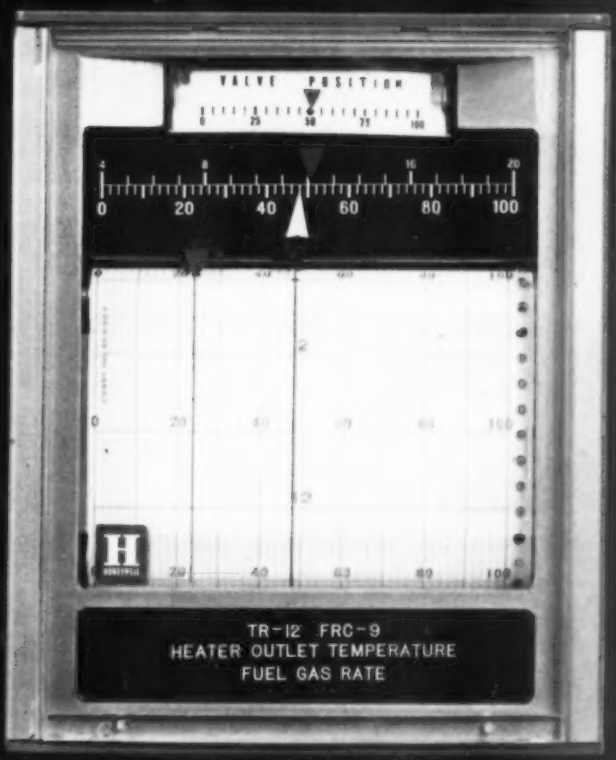
AURORA, ILLINOIS, U.S.A.

CONVEYORS . . . LOADERS . . . DITCHERS . . . ASPHALT PAVING EQUIPMENT

Here it is!

Honeywell's new *ElectriK Tel-O-Set** system

...the only true two-wire system for electric process control!



No line power connections in the field. The *ElectriK Tel-O-Set* system requires no external power at any field-mounted device and uses only two wires between it and the control room. These two wires form a series circuit that carries the measurement or control signal as well as the system's power. The only line power connection is made at the receiver.

Two-wire transmission sharply reduces installation costs. Add this to the fact that the *ElectriK Tel-O-Set* system's d-c transmission eliminates the need for shielding the wires, and you have the simplest, most economical installation possible.

*Trade name, Minneapolis-Honeywell Regulator Company

H HONEYWELL

COMPARE *ElectriK Tel-O-Set* WITH ANY OTHER ELECTRIC CONTROL SYSTEM!

Here it is!

the new *ElectriK Tel-O-Set* system

. . . newest advance in industrial process control

A complete, integrated line . . .

Control *any* industrial process with the *ElectriK Tel-O-Set* system. It has been designed as a complete system, rather than as a collection of individual instruments. The line consists of 22 major units which permit local and centralized data presentation, adjustable cascade control, ratio control and many other auxiliary functions. *ElectriK Tel-O-Set* transducers make the line completely compatible with your present pneumatic instruments.

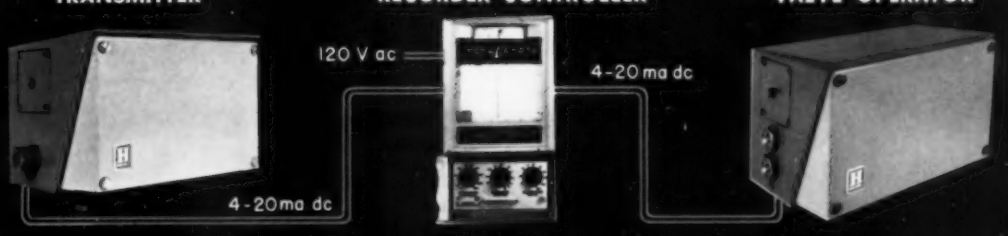
. . . built for industry

Die-cast aluminum cases and stainless steel components are used throughout the line to withstand the rough handling and demanding environments of industrial applications. Standardized components, together with extensive use of quick-connect and plug-in design, mean ready interchangeability of parts, reduced spare parts inventory, easy maintenance. The modular, or "building block" concept is employed throughout for maximum flexibility.

. . . this is how it works

The basic *ElectriK Tel-O-Set* system consists of a transmitter, receiver, controller and final control element. The transmitter measures any process variable, translates it into a standard 4 to 20 milliampere direct current signal, and transmits to the receiver through a pair of copper wires. The receiver indicates or records the signal in terms of the actual value of the process variable, compares it with a pre-determined set-point, and sends the difference to the controller as an error signal. The controller then converts this into a corrective 4-20 milliampere output to operate the control valve—again transmitting over a single pair of copper wires.

TRANSMITTER | **RECORDER CONTROLLER** | **VALVE OPERATOR**



All process and external electric connections to *ElectriK Tel-O-Set* field-mounted transmitters are entirely isolated from inside the case . . . to permit installation without the need for instrument department supervision.

All receivers, fron single-point indicator without control to two-pen ratio-cascade control station, are housed in the same case and all use the same panel cutout of 5½ x 6 inches. Controllers can be mounted with adjustments in front or back of panel.

All *ElectriK Tel-O-Set* field-mounted units . . . whether transmitter, transducer, or valve actuator . . . operate at ambient temperatures of —40 to 150° F. They all work on the same force-balance principle and use many similar components.

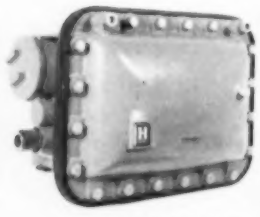
CHOICE OF THREE CASES

For field-mounted *ElectriK Tel-O-Set* units: Weatherproof for Division 2 locations; relay rack for mounting four abreast in a 19-inch rack, and explosion-proof for Division 1 locations.

All are completely transistorized and have quick-connect electric and pneumatic plugs.

Weatherproof

Relay rack



Explosion-proof

FR 2800a 471M

SYSTEM COMPONENTS

TRANSMITTERS
Process pressure to current (PP/I)
Differential pressure to current (Δ P/I)
Millivolt to current (MV/I)

RECORDERS
Single or two-pen recorders. Single or two-pen recording controllers with control, including simple cascade, on one pen. Two-pen recording controllers with ratio or cascade control on one pen.

INDICATORS
One pointer, with or without control
Milliammeter, with or without manual loading

CONTROLLERS
Two mode and three mode

FINAL CONTROL ELEMENTS
Current to pressure (I/P) valve operator
Electro-pneumatic positioner
Electro-hydraulic actuator

TRANSDUCERS
P/I: 3-15 psi to 4-20 ma dc
I/P: 4-20 ma to 3-15 psi
I/F: 4-20 ma dc to frequency
F/I: frequency to 4-20 ma dc

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Design for a Practical Safety Program

Stanley Owens
Director of Safety, Transcontinental Gas Pipe Line Corporation

IN writing this chapter on safety, I will, of course, draw upon the methods and techniques that have been used in Transcontinental Gas Pipe Line Corporation for the last 10 years. As this is written for the use of all natural gas pipelines, however, the various sections will be treated in a general way and should not be construed to be the exact methods or procedures used in the Transcontinental program.

Although this study will be on the subject of tailoring a safety organization to a pipeline company, it should be noted at the outset that the principles of good safety engineering apply equally to all industries, differing only in degree.

These safety organization standards will be divided into the following sections:

1. The Safety Department.
   Its place in the company organization.
   Responsibilities and functions of the safety director.
2. Employee Safety Training Meetings.
3. Accident Records and Analysis.
4. Accident Investigation and Recommendations.
5. Selection and Placement.
   Safety devices.
   Personal protective equipment.
   First aid supplies.
   Fire protection equipment.
6. First Aid Training Course.
   A practical short course in first aid, designed specifically for pipeline operation.
7. Inspection and Counsel.
   Work practices.
   Plant facilities.
8. Safety Training Material.
   Safety poster program.
   Sources and selection of material.
   Use of house organ.
9. Annual Safety Awards Program.

1. THE SAFETY DEPARTMENT

(a) Its place in the company organization.

A separate safety department should be established and the safety director placed in charge of this department. He should report directly to a member of top management, preferably the president or the financial vice president. In this manner, he will be free to contact all top management at any time on general problems and seek appropriations for the safety program. He should be free to make his own decisions regarding company safety policies.

Along these lines, the American Management Association made a survey of the status of the safety departments in 160 industrial concerns. Four out of five of these firms had a safety department. In 33 percent it was an independent department, reporting directly to top management. In 41 percent of these cases, the safety department was a subordinate section of another department. For the other 26 percent, it was combined with another department under some inclusive title.

There are defensible reasons for placing the safety department in or with a number of departments. As most accidents happen to employees in operations, why not put it under the operations department? As persons, through their unsafe acts, are responsible for most accidents, why not place it in with personnel?

As worker morale is an increasingly important factor, perhaps the safety department should be combined with industrial relations. Since safety records affect insurance rates, why not give jurisdiction to insurance?

Arguments for these several contentions are all cogent, and this fact itself might indicate that safety should be a separate department, reporting directly to top management.

For example, it might be argued, accident prevention is not the province of one department more than another. It is equally the province of all departments. It covers personnel, all operations, machinery, safety devices, physical structures, vehicles, and the pipeline. When the safety department is prominently identified with a single department, it may create the impression that its limitations are the same as those of the department with which it is combined. It is also true that the department with which the safety department is combined, unless it is working under a special executive order, will not carry the necessary weight with other departments.

A separate safety department established as a staff function and reporting directly to top management escapes these possible disadvantages. Staff status indicates the

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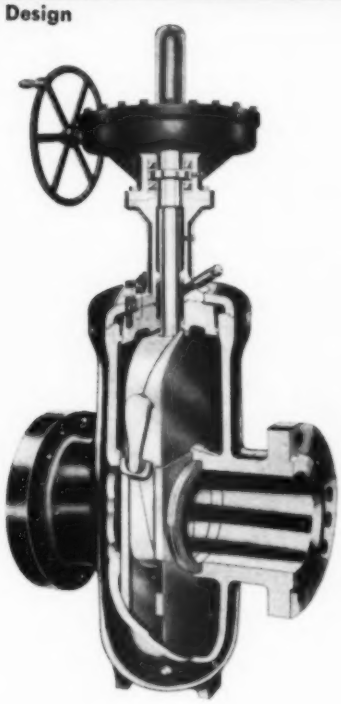

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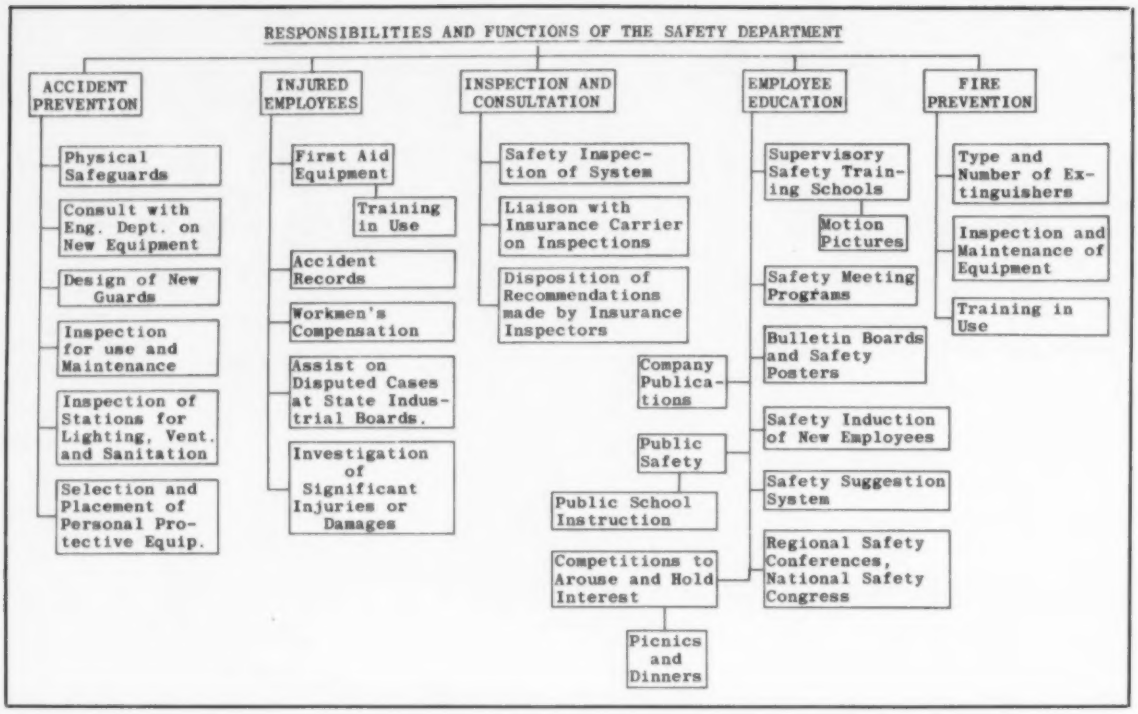

RESPONSIBILITIES AND FUNCTIONS OF THE SAFETY DEPARTMENT
ACCIDENT PREVENTION
Physical Safeguards
Consult with Eng. Dept. on New Equipment
Design of New Guards
Inspection for use and Maintenance
Inspection of Stations for Lighting, Vent. and Sanitation
Selection and Placement of Personal Protective Equip.
INJURED EMPLOYEES
First Aid Equipment
Training in Use
Accident Records
Workmen's Compensation
Assist on Disputed Cases at State Industrial Boards.
Investigation of Significant Injuries or Damages
INSPECTION AND CONSULTATION
Safety Inspection of System
Liaison with Insurance Carrier on Inspections
Disposition of Recommendations made by Insurance Inspectors
EMPLOYEE EDUCATION
Supervisory Safety Training Schools
Motion Pictures
Safety Meeting Programs
Bulletin Boards and Safety Posters
Company Publications
Safety Induction of New Employees
Public Safety
Safety Suggestion System
Public School Instruction
Regional Safety Conferences, National Safety Congress
Competitions to Arouse and Hold Interest
Picnics and Dinners
FIRE PREVENTION
Type and Number of Extinguishers
Inspection and Maintenance of Equipment
Training in Use

nature of its administrative position. Separate departmental status conveys the impression that safety activities are system wide and industry wide. The department's direct channel to top management makes it clear to everyone that the safety program is a top-priority program with the authority of management directly behind it.

In the stronger safety programs, where the safety engineer makes his own safety policy decisions, both frequency and severity injury rates are lower than in programs where safety policy is decided by a group.

Dean H. Mitchell, president of the American Gas Association, commented on October 31, 1955, in a letter to chief executives of gas utility companies: "As indicated in the attached article,* years ago many managements felt that accident prevention efforts were something akin to welfare work, efforts that were merely an adjunct to the work of the industrial relations section. Accident prevention was just another way to reduce worker grievances.

"There is one very interesting fact that I believe all of us should note in reviewing the article, and that is that efficient accident prevention efforts exist in those companies where the activities of the safety engineer and the safety department operate directly under the supervision of a top management executive. Reporting to and operating under the direction of a lesser management executive reduces the effectiveness of the safety engineer and his program."

*"The Safety Engineer in Industry, a Survey," Society for the Advancement of Management.

(b) Responsibilities and functions of the safety director.

Responsibilities. The safety director as head of the safety department is responsible for the planning and administration of a program for the:

Protection of employees and the public against bodily injuries and death arising out of the operation of the gas plant.

Safety and conservation of the gas plant including all stations, buildings and equipment, the pipeline, aerial and

Transcontinental was awarded First Prize at the American Gas Association meeting in St. Louis, Missouri, for this display of materials used in safety programs.

Robert W. Otto, president of American Gas Association, presents Transcontinental's Director of Safety, Stanley Owens, the 1958 Safety Achievement Award for having the lowest accident frequency rate of all member transmission companies in the United States with 1500 or more employees.

under-river crossings, self-propelled work equipment, automobiles and trucks against accidental losses or damages arising out of the operation of the gas plant.

Protection and conservation of public property against accidental losses or damages arising out of the operation of the gas plant.

Functions. The safety director and his staff shall:

Review each report of an employee injury, property damage, fire loss, or public liability. Maintain, study, and analyse these accident records.

Investigate immediately all accidents involving disabling injuries to employees or the public, accidents resulting in damage to company property or automotive equipment, fire and explosion losses. Advise responsible supervision on the results of accident or fire investigations, defining the causes and the methods to be followed to eliminate a repetition.

Maintain contact with company physicians along the right-of-way, advising them of the company's pre-employment physical examination standard and instructing them in the proper use of the form.

Maintain contact with claims adjusters throughout the system for the purpose of controlling disabilities on employee injuries.

Schedule insurance inspection of the gas plant to be made by the inspectors of the engineering department of the insurance carrier and arrange for a study of, and compliance with, their recommendations on fire protection and employee and public safety.

Arrange for compliance with requirements of regulatory bodies of the Federal Government and the various states with respect to safety matters.

Serve as liaison between the company and the National Safety Council as well as the Accident Prevention Committee of the American Gas Association; maintaining the company accident records in coded form and filing them with the Council and Association; incorporating in the company those plans or suggestions forwarded by these organizations if, after proper study, it is felt their use will be feasible and beneficial either from an employee or a public relations standpoint.

Develop and maintain an adequate and effective fire prevention and fire fighting program.

Make periodical inspections of the gas plant, including operations and new construction, from an accident prevention, damage prevention, fire loss, sanitation and employee health standpoint. Notify responsible supervisors of, and arrange for proper compliance with, and follow-up of, recommendations arising from these safety engineering inspections.

Plan and administer an employee safety and first aid training program throughout the system.

Select and provide adequate first aid supplies and arrange for the training of all employees in the proper use of such equipment.

Assist the legal department of insurance carrier in the presentation of disputed injury cases before state industrial commissions.

Maintain an adequate safety poster program, selecting posters and forwarding them for posting on safety bulletin boards located throughout the gas plant.

Prepare and supply monthly to the company house organ, safety engineering copy together with photographs of pertinent and significant safety operations in the field.

Plan for the control of physical hazards concerning the selection and placement of safe and properly guarded

Cover from Transcontinental's 1958 Annual Safety Report.

equipment, non-sparking tools, goggles and other employee personal protective equipment.

Establish standards and designs to be followed in guarding machinery and other equipment.

Plan, on a long range basis, for the re-design and replacement of obsolete equipment, the study of proposed new procedures for safety features and the improvement of methods and procedures from an accident prevention standpoint.

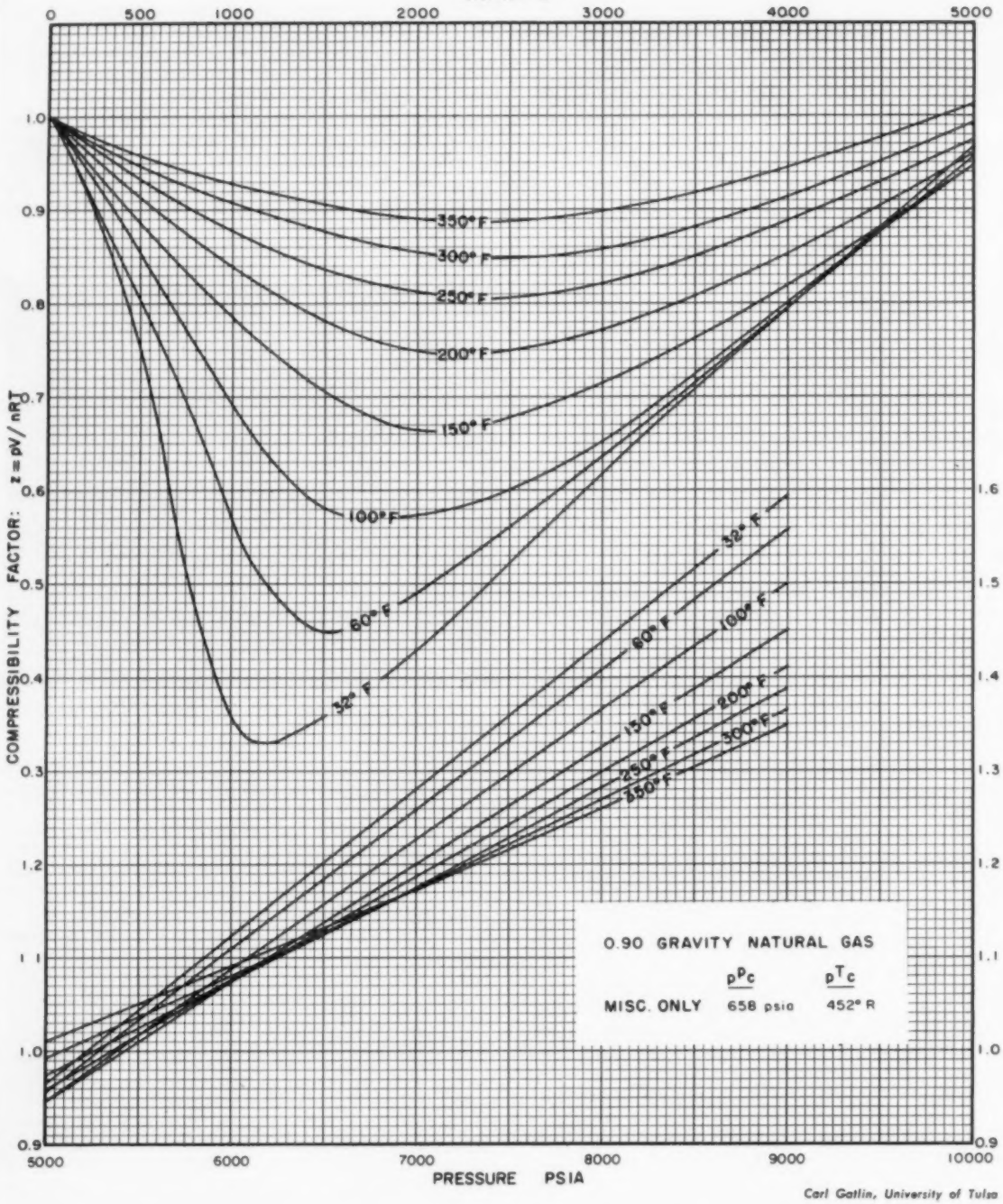
Prepare an annual report showing the status of the safety program. The annual report will summarize all accidents (broken down into Engineering, Communications, Construction, Land, Measurement, Compressor and Pipeline Department, and all others). This will reflect the safety training given by each superintendent to the employees in his station, district, or department. This report will mirror the cost of accidents through the frequency and severity ratings shown therein.

(To be continued in a forthcoming issue.)

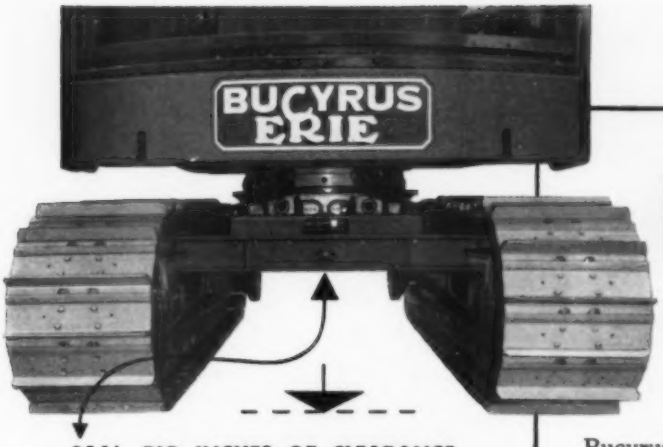
PIPELINE HANDBOOK **DATA SHEET** FILE UNDER: *Natural Gas Data*

SIMPLIFIED COMPRESSIBILITY FACTOR CHARTS FOR NATURAL GAS CALCULATIONS

CHART 6



Carl Gatlin, University of Tulsa



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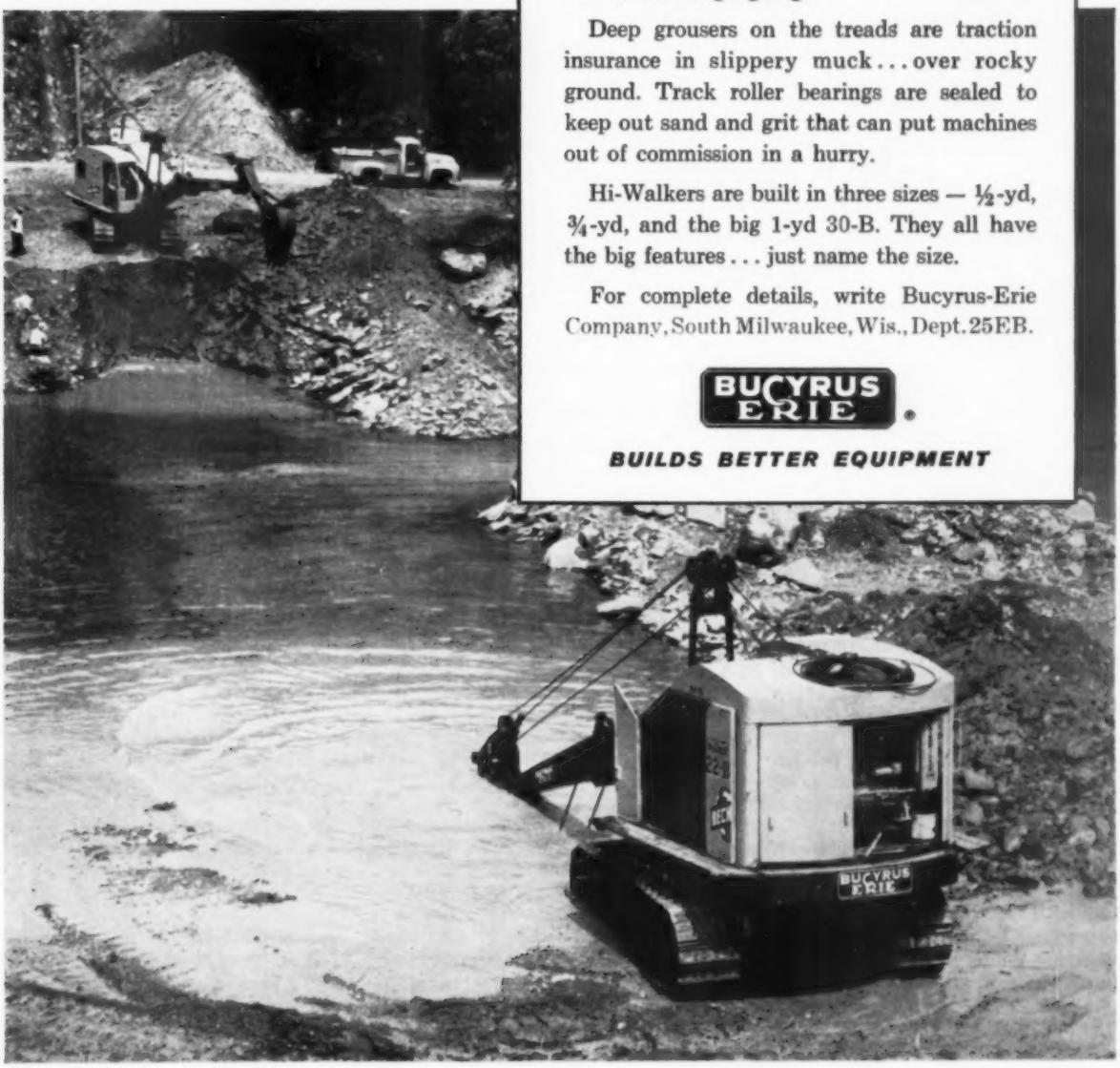

FIG. 1. Early tong gang laying 6-in. field line.

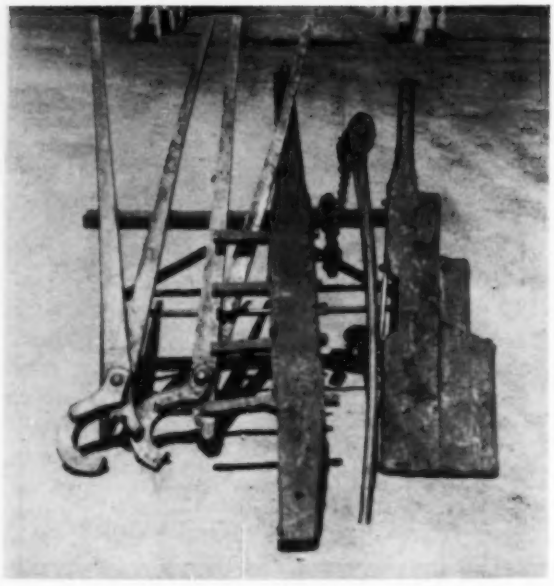

FIG. 2. Early-day pipe laying tools . . . lay tongs, pipe jack, chain tongs, and jack board.

Fifty Years of Progress in Pipeline Operations

Part 1.

Present trend is to break with traditional evolutionary type of progress and move ahead faster

Wallace K. Luse
Head, Civil Engineering Group
Interstate Oil Pipe Line Company

DURING 1959, Interstate Oil Pipe Line Company, together with its predecessor companies, will complete 50 years of crude oil transportation service to the petroleum industry. On this 50th anniversary it would seem timely to review our progress, not only as one company, but as an industry. Because of close association, some of the observations made here will be peculiar to this one company; however, many will be representative of the oil pipeline industry as a whole.

Webster defines PROGRESS as: Movement forward, Advance to an objective, Getting ahead, Gradual or Progressive betterment.

Few individuals or companies deliberately set out to "progress." Exceptions, of course, are those who modernize facilities as a result of the pressure of keen competition or conduct research. Most progress is of a gradual or evolutionary nature, occurring a "step at a time" so as to constitute a minimum break with tradition. Generally, oil pipeline progress has been this steady, but slow, method. There have been times in our history, however, when there has been a definite trend to break with tradition and move faster. This trend has been apparent during the last 10 years and was also evident during the boom years of the 1920's.

Progress may be the effect of aggressive management or engineering staff, alert operating personnel, economic conditions, or other factors. Regardless of the cause, the results are good, and many people benefit. The shipper benefits from reduced tariffs and pipeline allowances, sharper batch cuts, less contamination, and improved scheduling. The pipeline company benefits from lower operating costs, reduced evaporation and oil losses, and improved relations with the shipper.

Employment

Progress results of which we are most acutely aware are those that directly affect us or those with whom we work. In the early days, the pipeline industry work week was the same as other heavy industry; that is, 12 hours a day, 7 days a week. About 1916 the work day was reduced to 8 hours. The 6-day week came into being in the pipeline industry about 1928 and the 5-day, or 40-hour, week in the early 1930's.

Extraordinary circumstances have altered the 40-hour week at two different times since then. During the depression years, the week was reduced to 36, 35 and, in some cases, to 32 hours. The week was increased beyond 40 hours for many employees during the war years, but the 40-hour week

FIG. 3. An early-day pipeline tent camp in Louisiana swamp.

became established as the standard for the industry.

Various "plans" have been placed into effect over the years to aid the employees' welfare. In the early 1920's safety programs were started, and annuity plans were started even earlier. Most companies now have medical staffs. Among the many functions of this staff is the giving of periodic physical examinations. Group medical and hospitalization insurance is generally available to pipeline company employees as is group life insurance.

Programs were instituted as early as the 1920's which made it possible for the employees to share in the companies' profits. Among these are suggestion systems, stock acquisition plans, and thrift or profit sharing plans. These tend to make the employee feel that he is a part of the company and develops a keener interest in his job.

Line Pipe

The first successful pipelines were constructed from wrought iron pipe, which was manufactured by a laborious hand process known as puddling. The unit of manufacture was small and, due to the considerable human element in the process, a uniform product was impossible.

The "Bessemer Process" for steel making was introduced in 1855 and the "Open Hearth Process" in 1861. These developments permitted manufacture largely by machine methods and yielded a much more uniform product. It was not until 1887, however, that these methods were applied to the manufacture of pipe.

Interstate's predecessor companies laid the first lines in 1909 with "lap-weld" pipe made from open hearth steel. These lines were mostly 8-in., and the joints were connected by the screw coupled method.

FIG. 4. Pipe bender of days gone by.

Grade "B" seamless pipe was first used about 1927 and became the standard for the pipeline industry. A substantial amount of the pipe laid today is from Grade "B" material, either seamless or with an electric welded seam.

In the early 1940's, the "X" grade steels came into use for line pipe. These materials, X-42, X-46, and X-52 permit considerably higher operating pressures or the use of thinner wall pipe.

New steels are under development and test that are almost twice as strong as X-52, or about the equivalent of X-100. These undoubtedly will eventually be used in the manufacture of line pipe. Lines using X-60 steel, in all probability, will be laid before this year is out.

Twelve-inch pipe came into general use about 1915, and sizes have grown steadily since that time. Domestic oil lines of 20-in. and over are not uncommon, and several lines in foreign countries have been laid with 30-in. and larger.

High tensile, large diameter pipe makes possible wider station spacing and higher operating pressures and permits the movement of more oil at reduced cost.

Pipeline Construction

Advances made in pipeline construction methods have been just as dramatic as those made with pipe materials. In the early days, pipe was shipped by rail to the nearest possible point to the proposed line. From this point on, it was wagons, teams, and strong backs. Rights-of-way were cleared with saw and axe; ditches dug with pick and shovel; the screw pipe was put together with tongs; the coating, if any, was applied by brush or sling; and backfilling was done with a "Morman board," all in the hands of the workmen. Fig. 1 and 2 show a tong gang and their tools.

Practically all early pipelines were laid by company gangs. Tent camps were maintained along the right-of-way to shelter and feed the workmen. (See Fig. 3.) The quantity and quality of the food in the camps was for many years a favorite topic of conversation when old pipeliners got together. Undoubtedly, this food did much to keep the men on the job in the remote and rugged country crossed by the pipelines.

About 1918, the first piece of mechanized equipment appeared to take some of the load off the aching backs. This was called a "pipe laying machine." Actually, the machine did not "lay" the pipe. It was a machine that screwed the joints together by power from a gasoline engine. This one piece of equipment reduced by one-half the

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number of men required in the earlier "tong gang." During the next 10 years, pipeline construction became essentially a mechanized operation. Improved screw machines, called "Mahoneys," ditching machines, trucks, tractors, dozers, coating and wrapping machines, and bending machines took over much of the work. Fig. 4 shows an early bending machine.

Even though the screw coupled joints made possible a workable pipeline, no amount of care during construction could satisfy the need for a completely leak-proof line. Welding was, of course, the obvious answer.

The Author

Wallace K. Luse *is presently head of the Civil Engineering Group in the General Engineering Department of Interstate Oil Pipe Line Company. He joined Interstate's predecessor, Standard Oil Company of Louisiana, in 1939 and has worked in various capacities, including machinist, mechanical department field engineer, research engineer, and economics and evaluation engineer. His pipeline career was interrupted from 1941 to 1947 when he served in the U. S. Army Corps of Engineers where he attained the rank of lieutenant colonel. He earned his BS degree in mechanical engineering at Louisiana State University, is a registered mechanical engineer in the State of Louisiana, and is a member of the American Society of Mechanical Engineers.*

During the 1920's, welded joints replaced the screw joint except for small diameter and very low-pressure lines. The acetylene gas method was first employed; however, it was soon replaced by the electric arc method, which, with improved electrodes, is still in use. Development work is now underway to make the welding process automatic.

As pipe diameters increased, the size and cost of construction equipment grew to the point that it became uneconomical for pipeline companies to own because it would stand idle a large part

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

FIG. 5. Applying coating by brush.

of the time. This brought into being the pipeline construction companies or "pipeline contractors."

The contractor uses his equipment on one job, then moves it on to another so that it is in use a much greater portion of the time. He is in a position to keep abreast of the latest procedures and techniques and is able to keep certain specialists in his employ, which are necessary for economical and quality construction. The net result is a better and less expensive pipeline.

Corrosion Control

It was not long after the application of steel to buried pipelines that it was recognized that some method was needed to prevent corrosion or "rusting." This problem was not nearly so critical in the early days when wrought iron pipe was used, as wrought iron has some natural resistance to corrosion. With the advent of steel pipe, however, corrosion became a serious problem in some locations.

An early attempt to cope with the problem was to provide a "corrosion allowance" or extra thickness in the pipe wall. This was not a very satisfactory solution as the corrosion usually occurred in the form of pitting or localized corrosion rather than occurring uniformly over the pipe surface. The practice became well established, however, and it has only been in recent years that it has been abandoned.

Every old timer knew that a little oil would keep the trusty squirrel rifle from rusting, so it was only natural that oil should be tried on the pipeline. In some cases, it was heavy, black crude oil. Ship bottom paint, coal tar cutback liquids, asphalt base liquids, and, later, emulsified asphalt were tried. These were brush or sling applied at atmospheric temperature or heated slightly so they would spread easily. Most were applied directly to the pipe; however, occasionally, a primer was used. Fig. 5 shows coating being applied by brushes.

Interstate's lines laid in 1909 and 1910 were coated with ship bottom paint and coal tar liquid, applied by brush or sling. It was soon found that very little protection was being obtained so, beginning about 1914, many miles of line were encased in concrete. After the ditch was dug, the line was lowered-in to rest on small squares of concrete or "pads." A wooden form was erected on either side of the line and the space between filled with concrete. The bottom of the ditch served as bottom of the form. This method was used extensively until the middle 1920's. (See Fig. 6)

FIG. 6. Concrete coating a pipeline in early 1920's.

After it was found that the thin liquid type coatings soon disappeared, attempts were made to develop heavier coatings. Heavy petroleum grease coatings were used extensively during the late 1920's and early 1930's. Other procedures included multiple coats of various materials with and without wrapping materials between the coats and over the final coat. Hundreds of coatings appeared on the market, and companies set out to test as many as possible. In many cases, it took several years to make an evaluation, and in the meanwhile, other new products had appeared. The amount of data collected became enormous, much of which was inconclusive or conflicting. While this was going on and companies were trying to decide what coating to use, pipelines were rusting away, and leak rates were growing.

In 1930 the American Petroleum Institute, together with the coating manufacturers and the U. S. Bureau of Standards, set up a program for testing coatings. This program ran for 10 years. The results of these investigations materially helped to clarify the value of coating types and resulted in fewer coatings of questionable effectiveness.

Enamel coatings have become the generally accepted standard for protection of pipelines; however, considerable quantities of asphalt-mastic type coatings have also been used. Most such coatings are covered by a wrapping material, usually impregnated asbestos felt, to protect the coating during laying process and from soil stress. In the late 1940's, the coatings were improved by the addition of woven glass fabric that was pulled into the soft coating to provide reinforcement.

During the last five years, several tape coating materials have appeared. At least two, polyethylene and polyvinyl chloride, are petrochemical products. New petrochemical coatings now being tested include epoxy and butoxy. There are applied in liquid state and cured either by heat or by a catalyst.

Early coatings were hand applied, either by brush or sling. Coatings are now almost entirely machine applied,

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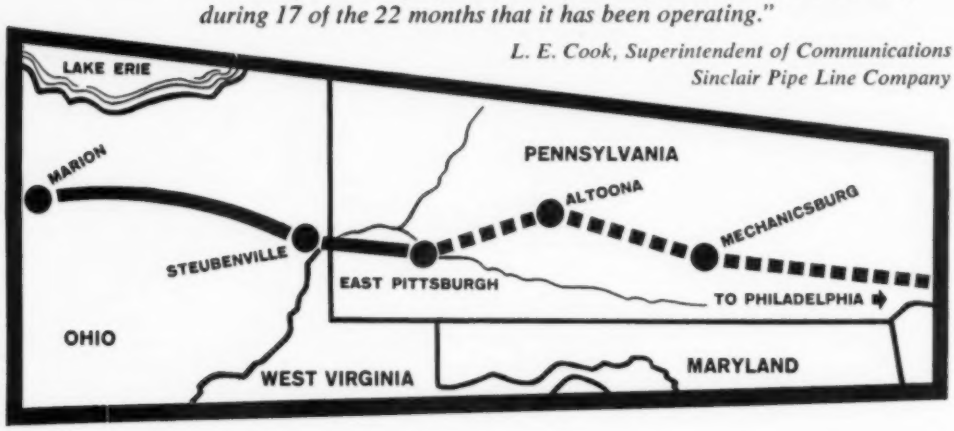
"...this system has performed exceptionally well...100% continuity during 17 of the 22 months that it has been operating."

L. E. Cook, Superintendent of Communications
Sinclair Pipe Line Company



Only five outages in the 22 months of service this Kellogg PTM Microwave System has been in operation for Sinclair Pipe Line Company, and only two of these totalling 2 hours and 51 minutes caused by the microwave equipment. That's 99.998% reliability, far superior to physical circuits!

Sinclair's dual path system was inaugurated on October 13, 1956. The present system stretches 200 miles from Marion, Ohio, to East Pittsburgh, Pennsylvania. It features 8 channels, 2 terminal stations, and 7 repeaters. All intermediate stations have drop equipment. At East Pittsburgh, circuits are joined by similar Kellogg 10C PTM systems extending eastward to Mechanicsburg then to Philadelphia.

Sinclair's dual path operation between East Pittsburgh and Marion, Ohio has many advantages over conventional systems, principally the elimination of all switch-over equipments or circuits. A failure of one of the units will not interrupt traffic, hence there is no traffic time loss as a result of switching to standby. There is increased reliability since both operating units are continuously monitored for condition of operation. Space or frequency diversity equipments may be operated with a minimum of additional components. In addition to this high degree of reliability and continuous performance, Sinclair reports that "the signal-to-noise measurements have exceeded the original calculations and the system has provided excellent performance since the inaugural date of operation."

The Kellogg Model 10C-2 PTM Microwave System now features up to 45 channel multiplexing equipments. Channels are readily arranged to suit the needs of specific installation whether for telemetering, remote control, data and voice transmission. Our engineering staff is always at your service ready to discuss your communication problems.

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1 Easy maintenance, particularly of the RF equipment; visual test and check methods may be used.

2 Tubes may be changed at random *without* realigning the Intermediate Frequency Amplifier.

3 Where propagation is a problem due to multi-path cancellation, it is simple to install space diversity reception equipment.

4 Drop channels may be installed at random, without need to demodulate entire groups to audio.

5 Economical system design: drop and insert channels may extend only throughout those parts of the system where required, and not the entire length.

6 Maximum transmitter tube life; tube life averages approximately 15,000 hours for 2C39s.

7 All PTM channels are interchangeable, only one spare is required.

8 High signal-to-noise ratio: the inherent noise of each channel is "clipped" out. Each terminal and each repeater station transmits a fresh signal.

9 Less tower rigidity required for accurate signal transmission at 2000 mc.

10 Plug-in channel units feature printed circuitry replacing tubes with crystal diodes; demodulators semi-passive, one tube per channel; modulators passive, no tubes. Results in 4:1 reduction in the number of tubes and 5:1 reduction in power consumption.

Investigate these and other advantages of a Kellogg PTM Microwave system. Write for complete details.

FIG. 7. Coating and wrapping machine of more modern vintage.

either over the ditch or in a coating yard. Fig. 7 shows a machine working over the ditch. Interstate first used yard coated pipe about 1931.

Even the best practical coatings leave something to be desired in the battle to mitigate corrosion. It is not economically practical to provide a "perfect" pipeline coating. The alternative is to provide a "good" coating and supplement it with cathodic protection. Interstate made its first attempt at cathodic protection in 1943, using wind generators; however, this method has since been abandoned in favor of anodes and rectifiers.

Early rectifier installations used scrap steel for groundbeds. These were soon replaced with carbon rod beds and, in some special installations, with high silicon cast-iron rods. Recently, considerable success has been had with deep groundbeds. The entire groundbed, including casing pipe, backfill material and rods, is installed in a single hole some 250 to 300 ft deep. This type bed has worked very well in many areas where conventional beds were unsatisfactory due to high resistance surface soil. It also has the advantage of requiring a minimum of ground area.

The use of improved coatings with adequate cathodic protection has reduced corrosion leaks almost to the vanishing point.

Transportation

Transportation of personnel, materials, and equipment has come a long way since Interstate's original lines were built in 1909 and 1910. An effort was made to locate the stations near a railroad because of the heavy equipment to be moved in; however, this was not always possible. Except where rail transportation was available, transportation between stations and along the pipeline was by horse, buggy, wagon, or on foot. In some few locations, boats could be used.

Because of transportation difficulties, houses were provided at pumping stations, at very nominal rental, for the married employees and a boarding house for unmarried and transient employees. Space was provided by the company for gardens and chicken yards, and employees were allowed to graze cattle on station tank farms.

Company owned automobiles were first purchased about 1916 and trucks the following year. The fleet of cars and trucks grew until practically all company transportation was by company vehicle. This is still true today of automobile transportation; however, the trend has reversed with regard to trucks. Light trucks are mostly company owned, but most heavy hauling is done by contract or truck freight. Some pipeline companies have found rented automobiles to be economical.

With the entry of pipelines into marsh areas, such as South Louisiana, boat transportation became necessary. Company owned boats are used to transport gagers on their daily jobs as well as maintenance crews, tools, and equipment.

Several companies have found it advantageous to use helicopters in certain phases of pipeline work. For example, helicopters, portable towers, and survey chains 1000 ft long have been used to survey pipeline routes through marsh lands. Additional uses for helicopters undoubtedly will be found. Many pipeline companies use executive type airplanes for transportation of key personnel.

(To be continued in an early issue)

Contract Right-of-Way Buying . . . How Does It Work?

A comparatively new phase of pipelining is explained by the man who initiated this type of service

John J. "Jack" Coates, *President*
Coates Field Service, Inc.

Editor's Note: *In most instances a pipeline company planning to lay a new line has its own employees contact landowners and procure easements. Most companies have a land department for this purpose, and it is the way the matter has been handled since the first pipelines were laid. That is, until recent years, when a new phase of pipelining entered the picture — that of contracting the purchase of right-of-way. To what extent has the idea caught on? How did it start in the first place? And, in what way, if any, does a pipeline company benefit by having an "outsider" handle this important detail for them?*

The author of this article was the originator of contract right-of-way buying, insofar as we know, and prepared the following at our request, to answer these and other questions about this little known subject, and delineate the methods of a company such as his.

"THE PAIN OF A NEW IDEA," sounds like a catch phrase with a humorous twist, but it is neither catchy nor humorous to the poor devil trying to sell an idea, and that's what I've been doing for the last 10 years.

In 1949 the Coates Abstract Company was rolling along doing a comfortable business, nearing its 50th birthday, occupying its own building in downtown Oklahoma City, and everybody was happy, including me, when along came an idea that was soon to change all that.

The idea was not originally right-of-way buying, but rather meeting title requirements for oil and gas companies, of which there are thousands operating in Oklahoma, and the title requirements we had in mind were those connected with oil and gas leases, not easements.

One of the first companies approached had been using our abstracting services for many years, but somewhere in the negotiations we got sidetracked and found ourselves talking about making the title search and buying the easements for a pipeline, of all things. This particular line was to run from a point in Texas to a refinery in Oklahoma, across a state line.

Now, we hadn't even thought of operating outside the State of Oklahoma, so here we did have a new and different set of conditions to consider. After toiling with all the problems, studying costs (later developments proved we were guessing) and settling on a firm proposal, the line was abandoned.

At any rate, the result of all the thought devoted to that first line put us in the right-of-way buying business, because we reasoned that if we could operate in Texas as well as Oklahoma, then we could function in any of the others. So we started contacting pipeline companies and wound up where? In the swamps of Louisiana.

Operating an abstract business in Oklahoma necessitates close association with the real estate business and oil and gas lease buying operations. These two businesses have always been handled by brokers working for a fee. In fact, when you think about it, many, many phases of American business are handled by brokers, and contract right-of-way buying is merely the application of a sound operating business principle applied to the acquisition of a land right by a third party (the broker), for a principal (the pipeline company), from the other principal in the deal (the landowner).

Simple? It does sound simple, but brother, the pitfalls! What with land costs continuing to rise each passing day the need for technical and professional handling of any type of land acquisition is becoming steadily more acute.

Selling the Idea

Earlier in this article the problem of selling this idea was touched upon, and it has been a problem; even though the idea is sound, has been proved practical by those who have tried it, and is a practice all major companies follow in handling engineering, construction, drilling, and heavy legal and accounting work.

The word "professional" also comes into the picture at this point. It seems industry thinks nothing of engaging professional services. In fact, it's a standard practice, but the professional right-of-way buyer for some reason or another is not included. Perhaps it is because the American Right-of-Way Association has only recently directed its efforts toward focusing the attention of the industry on the fact that right-of-way buying is a profession and its program has not yet had time to have a telling effect. Up until the time the American Right-of-Way Association took up the cause, our feeble voice was the only one calling this fact to the attention of those in policy-making positions.

The contract right-of-way buyer can perform a dignified, worthwhile, economical, clean, trouble and time-saving service to the pipeline industry. He is a third party. Grievance claimed by a landowner over former alleged mistreatment by the company can be heard from a dispassionate, objective position and dealt with accordingly.

Contractor vs Company Personnel

One problem that has been difficult for us to overcome is that of finding a really fair and equitable way to compare the results obtained from using a contractor as opposed to conducting

the program with company personnel. This is a business where details control costs and even determine the eventual success or failure of a program. It's easy for the outsider, or even some insiders, to say, "We bought a hundred mile line in Jericho three years ago and our average costs only came to $2.45 per rod, including services. How come you figure this 100-mile line in Timbuctu today is going to cost $8.92 per rod?"

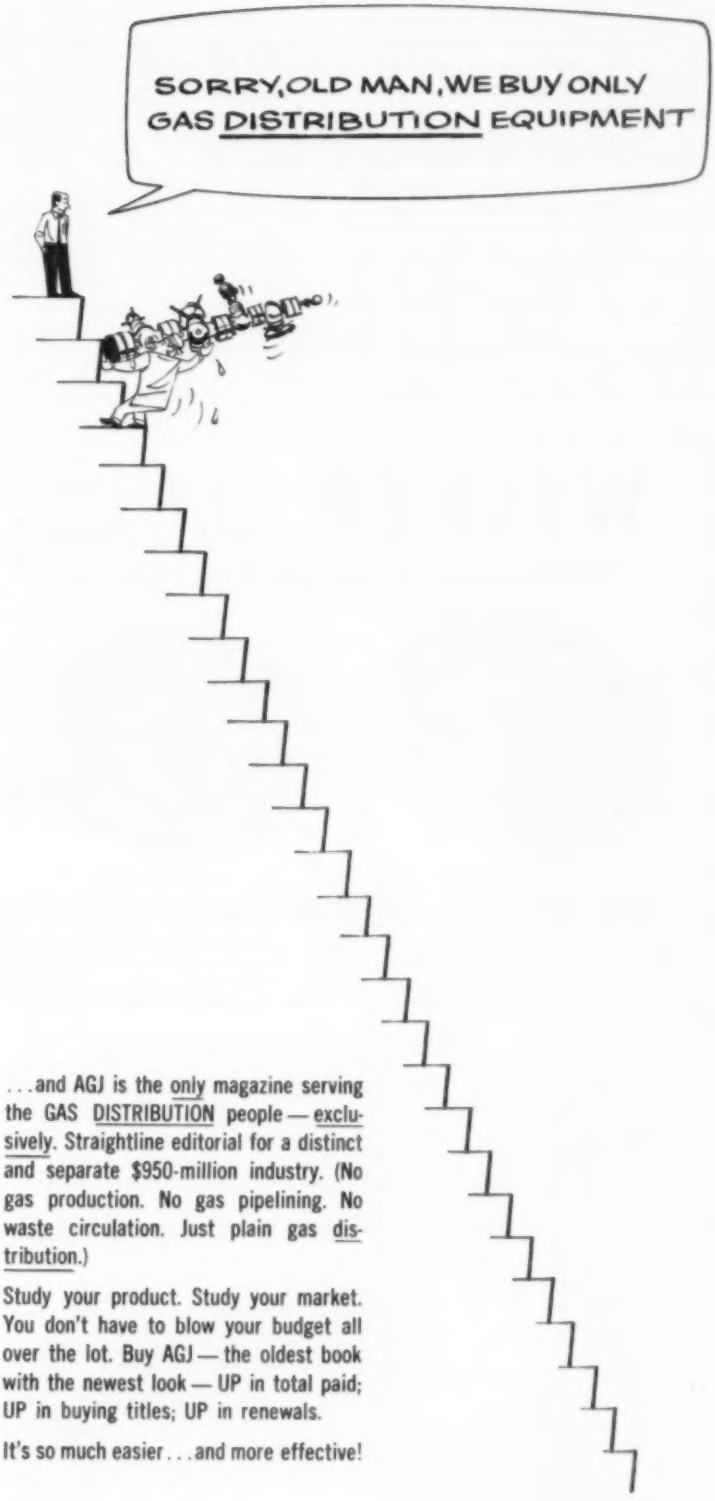
Off-hand this sounds like a good question, but perhaps the Jericho line was the first one ever built in the area, or perhaps it was a gas distribution line, maybe the land ownership count came to one every two miles, whereas the new line under study might be in an area laced with pipelines, might be a crude transmission line benefiting the landowners little, and the owner-

The Author

John J. "Jack" Coates *was born in Oklahoma Territory, October 17, 1906, in Oklahoma City, the son of J. S. Coates, who at that time was an abstracter, and later also was the first register of deeds in Oklahoma County after statehood. He recevied his AB degree from Oklahoma University in 1927. After graduation he joined his father in operating The Coates Abstract Company in Oklahoma City, and continued in this work after his father's death in 1937. He founded Coates Field Service, Inc., in March 1950, and operated it in conjunction with the abstract company until February 1952, at which time the abstract company was merged into The Coates-Southwest Title Company. It was then he plunged full force into the management of and started devoting active personal attention to the affairs of Coates Field Service, Inc. Recently his company became associated with Lockwood, Kessler and Bartlett, Inc., Syossett, Long Island, New York, an engineering concern, placing his company, Mr. Coates says, in a position to render services in engineering, design, surveying, mapping, photogrammetric survey, aerial photography, and lands and right-of-way acquisition.*

ship count might be four or five or even more to the mile. Also, the first line might have been in an area of low land values and the second in high value areas, therefore, trying to use these two lines as a basis for comparison merely because they were of the same length is ridiculous and tends to underscore how details affect the costs.

It must suffice to say that analyzing these details intelligently can result in real savings and accurate budgeting, but how to show management a way to measure such savings by enlisting our services remains a challenge. All, how-



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ever, agree that trained buyers in the field can produce real savings in time and money under any set of circumstances, and trained buyers are what we have sticking out of our ears.

Budget Studies and Planning

Our real value rests in assisting with budget studies and planning, enabling our principal to set up a program based on fact, thereby insuring successful and thrifty results. The real savings derived are not the difference between the right-of-way contractor's bids and the estimated costs of using company personnel. They are the difference between total costs for the completed program as accomplished by the contractor and what they would be if conducted by company permanent staff, augmented with temporary help among which there are always going to be a few "turkeys" to foul things up and increase overall costs.

To do our job creditably requires a first hand knowledge of land title peculiarities in all the 49 states. Our long experience and active participation for some 25 years in the affairs of the American Title Association were a great help of course. During our past work experience, however, we have gained first hand working knowledge of these details nation-wide.

Our manpower is handled like that of any other contractor; we staff each job as it is given to us with the agents we feel have the most suitable personality and qualifications for the job at hand. After several years in the business we have built a personnel record file from actual working experience with hundreds of the finest, thoroughly experienced, well-seasoned right-of-way agents in the country.

Our superintendents we try to keep in our employ the year 'round. We have been very successful in doing this as these men double in brass by becoming sales representatives between jobs. This is vital to our operation, as a good superintendent is an absolute "must" on every job we undertake. The high regard we have for them is evidenced by the fact that several of them are officers and stockholders in our company. As our operations grow and expand we intend to attract to our company more of these well-trained men.

Mature Buyers Preferred

Our theory of the best age for a right-of-way buyer is that found when his wife reaches middle age. Most landowners became such after they grew a little mature, therefore the agent has to have a little grey in his hair in order to talk business to them. I am not saying there is no place in our business for youth, but the average client expects us to staff his job with professional buyers. "Professional" means experience, so we can absorb a young man here and there, but the percentage is pretty low.

We are always on the look-out for men who have reached retirement age with their companies and have a lifetime of right-of-way experience behind them. We have found this a great source of trained manpower and it serves a dual purpose by being a benefit to us and our clients and utilizes a great many useful years of service these men would like to devote to their chosen profession, and to a useful life.

The "Glamorous" Life

In closing it should be pointed out that the life of a right-of-way buyer might be considered glamorous and fascinating, all this moving about from one part of the country to another, but those of you with a home and fireside to return to each night, don't realize the hardships and hazards, both physical and mental, that he must endure each day. Heat in the summer, cold in the winter, and irate landowners in between, and just when he's been in an area long enough to create a few acquaintances, it's time to move on. In fact, the plaintive, modern day, western ballad that fits him best is entitled, "I'm Moving On." ★ ★ ★

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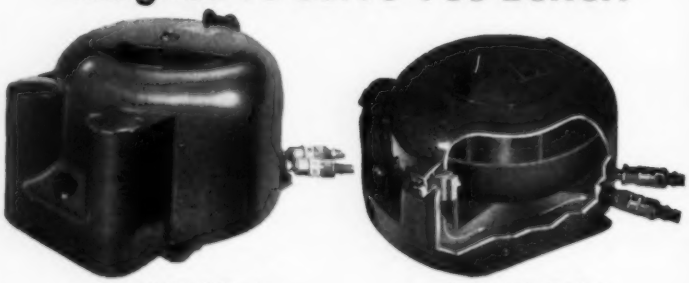

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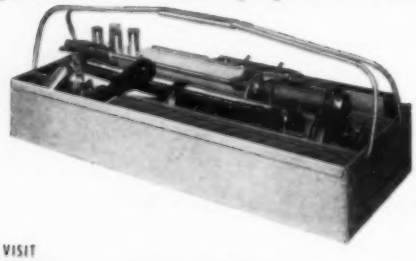

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Tennessee's Approach to Operation of a 'Ready-Remote' Gas Turbine Station

Over a period of almost two years, a new idea tried at Alexandria, Louisiana, has proved highly successful

Charles A. Falkenhagen and G. W. Goloby
Compressor Department, Tennessee Gas Pipeline Company

REMOTE OPERATION of natural gas pipeline compressor stations is approached in different ways by the various transmission companies. This article is intended to explain the approach of Tennessee Gas Pipeline Company, a division of Tennessee Gas Transmission Company, to the "Ready-Remote" operation of a gas turbine station.

During 1957 the company constructed on its 30-in. Kinder, Louisiana-Portland, Tennessee line a station to be remotely controlled. The station is near Alexandria, Louisiana, 65 pipeline miles from the master station at Kinder.

The remote station is on a 30-acre site, and future expansion should pose no problem with an area of this size. Station structures consist of a utility building, fuel meter building, compressor building, microwave equipment building, and two resident cottages.

Utility and compressor buildings are multipurpose. The utility building contains an office, warehouse, shop area, and employees assembly room. The compressor building consists of the compressor room, auxiliary-generator room, control room, and a basement.

A 6700-hp gas-fired turbine driving a centrifugal compressor is located in the compressor room. In the auxiliary-generator room are housed two 220-hp gas engines driving 187-kva generators, 92 d-c wet cell storage batteries and battery-charger, turbine and engine jacket water pumps, main bus, and switchboard. The turbine and compressor panel board, auxiliary equipment panel board, and supervisory equipment are in the control room.

Supervisory Equipment

The master station at Kinder houses the supervisory equipment in its auxiliary-generator building. This is a typical reciprocating engine station of 12,400-hp. The supervisory panel measures 24-in. by 24-in. by 7 ft 6 in. Charts record the remote station suction and discharge pressures, orifice meter differential pressure, turbine exhaust temperature, load shaft speed, high pressure shaft speed, and axial flow air compressor discharge pressure. Also contained in the panel are certain indicating lights and control keys (operating buttons). Control keys without indicating lights are:

1. "Trip-Lower" key
2. "Silence" key
3. "Reset" key
4. "Close-Raise" key
5. "Check" key

Indicating lights without control keys are:

1. Green "Start" light
2. Red "Alarm" light
3. Red, green, and amber "Station Check" lights
4. Red, green, and amber "Remote-Local Turbine Control" lights
5. Red, green, and amber "Remote-Local Nozzle Control" lights
6. Red, green, and amber "Annunciator Alarm" lights.

Indicating lights and control keys are used for the following points:

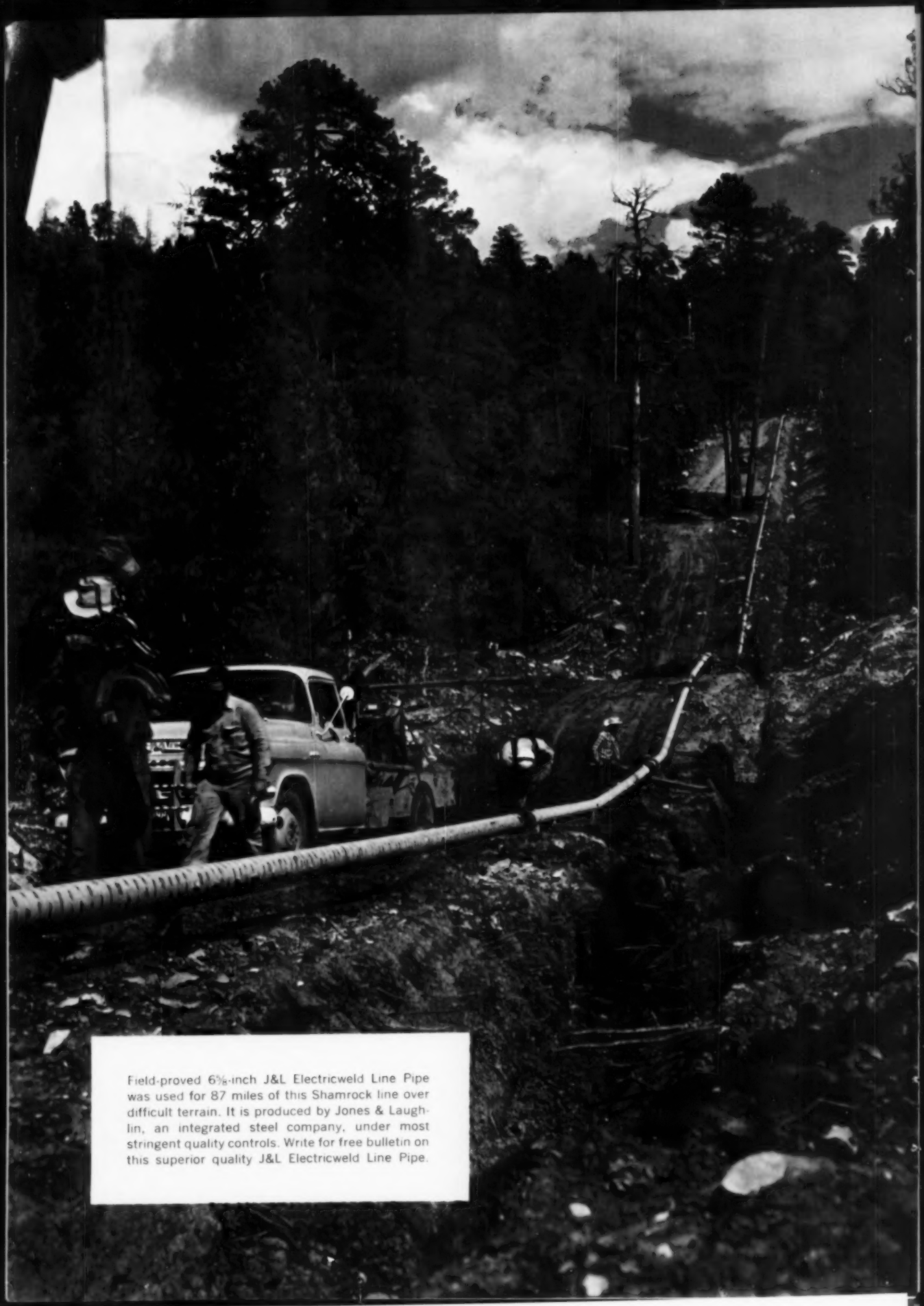
1. "Turbine speed (small) control" amber light and key
2. "Turbine Speed (course) Control" amber light and key
3. "HP Shaft Speed Control" amber light and key
4. "Start Turbine" green, blue, and amber lights and key
5. "Stop Turbine" green, red, and amber lights and key
6. "MLV Open-Close" green, red, and amber lights and key
7. "By-Pass Valve Open-Close" green, red, and amber lights and key.

The "trip-lower" key will stop the turbine, open valves or lower speed. The "silence" key will silence the alarm bell and extinguish the red alarm light. The "reset" key cancels any selection and returns supervisory controls to rest, also resets alarm on panel and returns flashing lights to steady state. The "close-raise" key will close valves, raise speed, or start the turbine. The "check" key is used to check the supervisory.

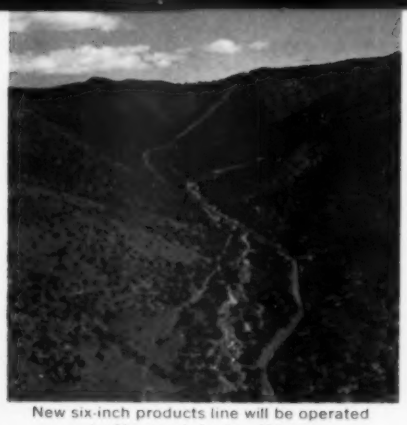
For the "close-raise" or "trip-lower" controls to be performed, two keys must be pushed. For example, to stop the turbine first push the "stop turbine" key. Its red light continues to burn and its amber light comes on (also the "start" green light goes out). Then push the "trip-lower" key and the turbine will stop and the "stop turbine" green light will come on (the "start" green light will also come on).

The turbine speed "small" and "course" controls refer to the load shaft and will change its speed 25 to 100 rpm, respectively.

The lights are used to indicate a state of readiness or position and also to indicate a control or check in progress. The "start" light burns green steadily when no control function is being performed and goes out with a function in progress. Amber lights are used to confirm a selection or check.



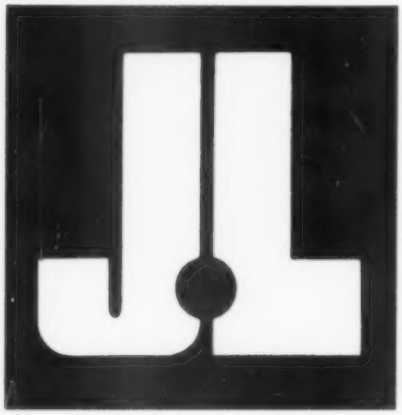
Field-proved 6⅝-inch J&L Electricweld Line Pipe was used for 87 miles of this Shamrock line over difficult terrain. It is produced by Jones & Laughlin, an integrated steel company, under most stringent quality controls. Write for free bulletin on this superior quality J&L Electricweld Line Pipe.



New six-inch products line will be operated by Shamrock for its affiliate, West Emerald Pipe Line Corporation.

Welders on this Shamrock line reported that J&L Electricweld Line Pipe was uniformly round, easy to weld.

Pipe is produced under strict compliance with appropriate A.P.I. and A.S.T.M. specifications.



Contractors for the rugged section from Palma, N.M., to Albuquerque were Groninger & King, Pampa, Texas.

Pipe is A.P.I. Standard 5 LX, Grade X 42, 12.89 pounds per foot, with a .188 inch wall thickness.

"Superior weldability of J&L Electricweld Line Pipe was proved on this mountainous operation"

. . . reports pipe line contractor

Steep, mountainous terrain presented a real challenge to pipeliners working on this Shamrock Oil and Gas Corporation line from Amarillo to Albuquerque. Eighty-seven miles of $6^{5}/_{8}$-inch J&L Electricweld Line Pipe were used in the rugged section from Palma, N.M., to Albuquerque. Performance proved conclusively that J&L Electricweld Line Pipe bends readily to contour, is easy to weld and is uniformly round. It is readily available from $6^{5}/_{8}$ inches through $12^{3}/_{4}$ inches.

Jones & Laughlin Steel Corporation

PITTSBURGH, PENNSYLVANIA

J&L Electricweld Line Pipe is produced on one of the most modern mills in the world.

Hydrostatic test is one of a series of inspections and tests given every length of pipe.

This modern J&L ultra-sonic tester assures superior weld quality.

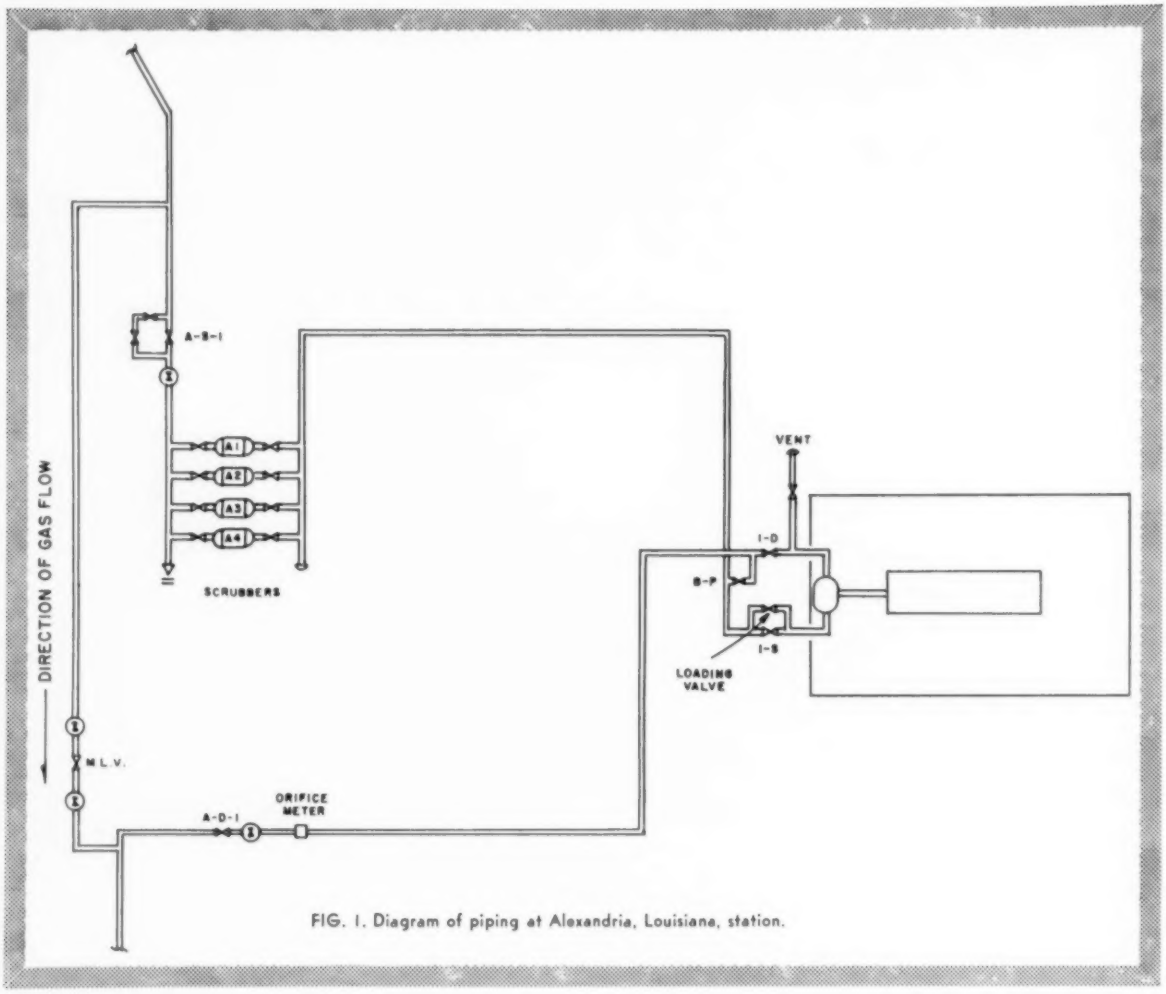


FIG. 1. Diagram of piping at Alexandria, Louisiana, station.

The blue indicating light burns as the turbine goes through its starting sequence.

The "check" key is used before each start and at frequent intervals during operation to indicate that the supervisory equipment is working properly and that the microwave system is in order. If the microwave system fails, the alarm bell will sound, there will be no burning lights, and speed and pressure receivers will indicate their maximum values, but the turbine will continue to run.

Signals Carried by Microwave

Signals necessary to operate the remote station are carried by a microwave system which the company owns and maintains. This system requires four towers, one each at the remote and master stations, and two intermediate towers. At each intermediate tower the signals are received and retransmitted. Electric power for these two towers is purchased. To eliminate loss of the microwave equipment because of power failure, a small engine generator was installed at each intermediate tower. These generators will come on with loss of purchased power and shut off when purchased power is restored. To assure the performance of the standby units the purchased power supply is disrupted for 15 minutes each week to allow the engine generator to run.

The microwave system connects the master and remote stations with a voice circuit. The remote station also has telephone, radio, and teletypewriter equipment for other means of communication. Radio and teletypewriter are situated in the remote station's office and generally are used during daylight hours only.

Turbine Starting Sequence

Turbine starting sequence is comparable with that of any present day turbine. Tennessee's piping and valves are shown in Fig. 1. The master station has control of only the bypass and main line valves.

The remote station attendant must purge and load the turbine station yard piping up to the compressor suction and discharge valves. The bypass valve is opened to remedy a surging condition detected by a low differential signal at the orifice in the discharge line. Such a low differential signal sounds the alarm at the master station.

The main block valve and all valves on the station side of the pipeline are equipped with valve operators. For the Kinder station to start the turbine the "remote-local turbine control" switch at the remote station must be so positioned, and can only be done so at the remote station. This provides the remote station with the advantage that in case of emergency the turbine can be taken away from the master station immediately. (Should this be done the master station should receive an alarm.)

To start the turbine from the master

station, the "start gas turbine" button is pushed first, then the "close-raise" button is activated. When this is done, the following events occur at the remote station.

Auxiliary a-c lube oil pump starts.

A-C turbine nozzle water pump starts.

Circulating cooling water pump starts.

Atmospheric cooler fans start.

Seal oil pump starts (when suction press equals 5 psi).

D-C controls and standby pumps are energized.

When seal oil pressure is normal, the loading valve opens (vent valve is already open) and remains open for 2 minutes to purge the compressor case.

Vent valve closes and case pressurizes through loading valve.

When case pressure equals line pressure, suction valve 1-S, and discharge valve 1-D open, and the loading valve closes.

Discharge side valve A-D-1 opens.

When valves A-D-1, 1-S, and 1-D are fully open, gas is admitted to the starting turbine, and the high speed shaft begins to turn. (All three of these valves must be open.)

Starting turbine accelerated to 1800 rpm.

The turbine purges itself for 5 minutes.

Turbine fires, speed of high speed shaft increases, and exhaust temperatures rise.

After 2 minutes warm up, the high speed shaft comes to 4000 rpm and the load shaft to 3600 rpm.

The turbine is ready to load when the "stop turbine control" red light burns steady and the load shaft is at 3600 rpm.

The operator at the master station will then push the "MLV open-close" key, its amber light will burn steadily and the green "start" light will go out. He then pushes the "close-raise" key and when the MLV closes its amber light goes out, its red light burns steadily and the green "start" light comes back on. The turbine is now on the line and the Kinder operator increases its speed by selecting one of the two "turbine speed control" keys and the "close-raise" key to obtain ordered discharge pressure.

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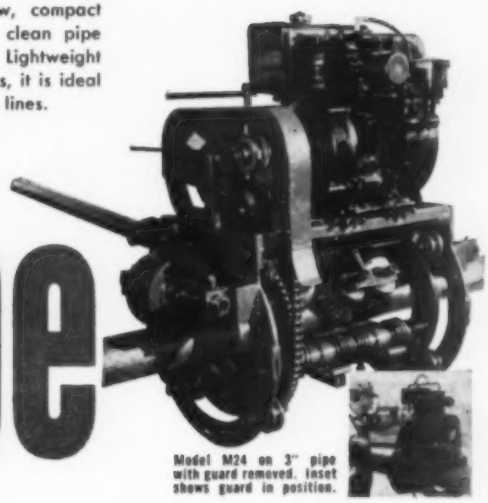

Model M24 on 3" pipe with guard removed. Inset shows guard in position.

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Turbine Shut Downs

The following annunciator alarms will shut down the turbine and vent the compressor case automatically, but will leave the yard piping pressurized:

1. High turbine exhaust temperature.
2. High speed shaft overspeed trip.
3. High speed shaft vibration excessive.
4. Load shaft overspeed trip.
5. Load shaft vibration excessive.
6. High discharge gas pressure.
7. Low seal oil pressure.
8. High nozzle water temperature.

If the turbine goes down for any reason including those listed above, the alarm immediately notifies the operator at the master station. Once the turbine goes down it cannot be restarted from Kinder until the device causing the failure is repaired and the annunciator at the remote station is reset. When any of the above eight conditions occur, valves A-D-1, 1-S, and 1-D will close and the compressor vent valve will open. The operator at the manual station must open the main line valve when the pressures across it are equalized. It was with the valves in this position that the turbine was started previously.

Malfunctions that shut down the turbine and also vent the yard piping are:

1. Loss of seal oil pressure.
2. Loss of a-c power.
3. Fire-eye protective device actuated.
4. In addition, the remote station attendant may operate either one of the two emergency shut down valves.

The first three failures will be indicated on the annunciator in the remote station control room. The fire-eye device is initiated by any flashing of light between 5 and 30 cps regardless of the source. Various light reflections have shut down the station. Since the station has been in operation, it has been satisfactorily shut down by each of the emergency devices, except the manual emergency shut down valve.

Emergency Shut Down System

The emergency shut down system is simply a pressurized 2-in. line. This pressure is maintained by gas flowing

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into the line through an orifice. Pressure is maintained against the valve operators that must operate during an emergency. In an emergency the pressure is released through the manual vent valve or valves and the operators will open or close the valves as the case may be. The orifice is so small that the line cannot repressurize until the vent valve is closed.

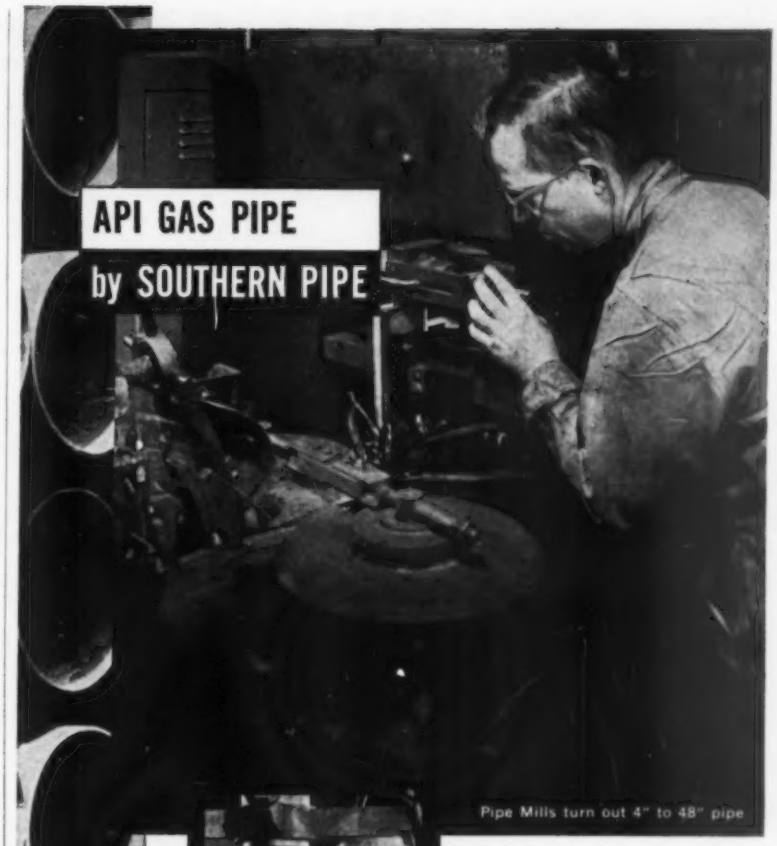
Two manual emergency vent valves are strategically located in the remote station yard. This remote station is a manned station with eight employees including two supervisory personnel. Five of these employees are on a shift basis. By having an attendant at the remote station on duty at all times the master station has immediate contact around the clock with the remote station. An attendant at a master station may be hesitant to arouse someone at night to clarify a minor question that has arisen in a truly remote operation; however, he feels free in this case to question the remote station attendant who is there for that purpose.

The primary duties of the remote station employees are of a housekeeping and maintenance nature. Buildings and equipment have to be maintained, painted, and kept in a good state of repair. Also, the station yard must be maintained. In conjunction with these duties the eight employees are responsible for the maintenance and operation of 70 miles of pipeline right-of-way.

The remote station is protected by every safety device felt necessary at this time, which frees the employees to perform duties away from the compressor building that otherwise would call for extra labor. While on tour the remote station attendant reports to the master station as often as once each two hours to simply check in and discuss any questions either location may have.

Addition of the supervisory equipment at the master station and the responsibilities that accompany its operation did not require any additional personnel. The master station operator has always reported to the Houston office dispatcher each hour pertinent information about his station, over the leased line telephone located in the auxiliary-generator building. With the supervisory equipment for the remote station also in this building, it is simple for him to check this equipment, fill in the remote station log sheet and give this information to the dispatcher as well.

The ready-remote operation of the Alexandria station has been highly successful, demonstrating that a localized master station can control effectively and efficiently remote turbine stations on either side of it. ★ ★ ★



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WITH THE PIPELINE CONTRACTORS

CONSTRUCTION

FEATURE

● **Associated Pipe Line Contractors, 3115 Buffalo Drive, Houston Texas.** Has been awarded contracts by *The Rotterdam-Rhine Pipeline* to build 59 miles of 30-in. and 96 miles of 24-in. crude line from Rotterdam to Godorf and Wesseling, Germany, and a 25-mile smaller line to a Gelsenkuchen refinery.

● **B & M Construction Corporation, 2808 First National Bank Building, Oklahoma City, Oklahoma.** Has been awarded a contract to build 218 miles of 8-in. line for *National Iranian Oil Company* from Tehran to Resnt, Iran.

● **Brown & Root, Inc., 4100 Clinton Drive, Houston, Texas.** Has contract with *Texas Eastern Transmission Corporation* to furnish field supervision for construction of 626 miles of 30-in. loops along the company's line between Beaumont, Texas, and Uniontown, Pennsylvania.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has been awarded a contract by *Northern Oklahoma Gas Company* to install 70 miles of 10 and 12-in. line between Cherokee and Ponca City, Oklahoma; and has been awarded a contract to construct 62 miles of 8-in. petroleum products pipeline connecting the *Texas Eastern Transmission Corporation* refinery at Tyler to the Little Big Inch pipeline system at Carthage. Has contract also to construct 93 miles of 8 to 20-in. gathering system from Falfurrias to McAllen, Texas, for *South Texas Natural Gas Gathering Company*. R. M. Jones is spreadman, with field office at Falfurrias.

● **Clear Span Engineering Company, Inc., 4118 Fannin, Houston, Texas.** Has contract from *Houston Texas Gas & Oil Corporation* to design the bridges and furnish towers and cable systems for the following five crossings: Pearl, 520 ft; Pascagoula, 640 ft; Escambia, 640 ft; Apalachicola, 960 ft; Suwanee, 660 ft.

● **Coates Field Service, Inc., P. O. Box 1581, Oklahoma City, Oklahoma.** Has contract for right-of-way acquisition for the *Peoples Natural Gas Company* on their 30-mile gas line located between Gibson and Imperial, Pennsylvania.

● **Conner Construction Company, P. O. Box 1047, Odessa, Texas.** Has been awarded a contract to construct 54 miles of 3-in. natural gasoline line for *Phillips Petroleum Company* from a Crane County gasoline plant to near Fort Stockton, Texas.

● **Dunn Brothers, Inc., 801 Mercantile Securities Bldg., Dallas, Texas.** Has received a contract from *Tennessee Gas Transmission Company* to unload and rack pipe near West Point, Kentucky. Keith Lee will supervise.

● **Engineering-Construction Company, First National Bldg., Tulsa, Oklahoma.** Has contract from *Jayhawk Pipeline Corporation* to construct 44 miles of 6-in. crude pipeline, 12 miles of 4 and 3-in. gathering line, and one pump station, all to serve the Pleasant Prairie Pool located near Garden City, Kansas.

● **Fulghum Contracting Corporation, P. O. Box 1181, Harrisburg, Pennsylvania.** Has been awarded a contract to lay 100 miles of 12-in. pipeline from Watertown to Massena, New York, for *Niagara Mohawk Power Corporation*.

● **R. H. Fulton & Company, P. O. Box 1526, Lubbock, Texas.** Has been awarded a contract by *Michigan Wisconsin Pipe Line Company* to build 211.7 miles of 24-in. pipeline in Kansas, Nebraska, and Missouri. Also has contract from *Northern Natural Gas Company* to lay 11 1/10 miles of 30-in. pipeline north of Sunray, Texas, and 8 1/10 miles of 30-in. north of Beaver, Oklahoma, with A. A. Carrigan as job superintendent in the field office at Beaver.

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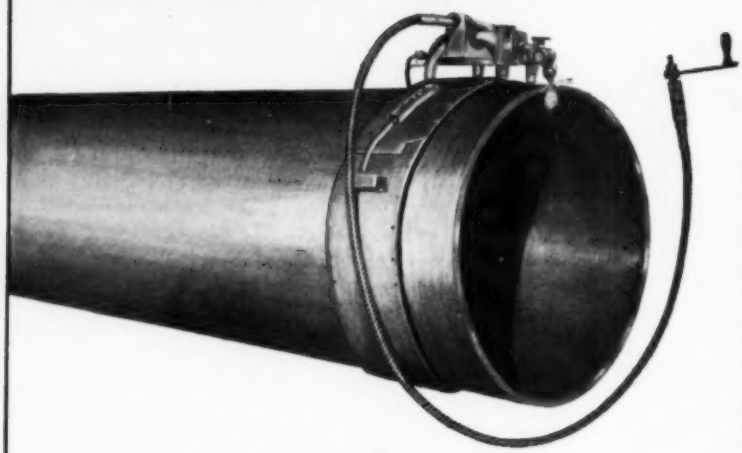
BEVELS 48" PIPE



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Contractors

● **H. L. Gentry Construction Company, 921 East Michigan, Jackson, Michigan.** Has been awarded a contract by *North Carolina Natural Gas Corporation* to construct in excess of 163 miles of pipe ranging in size from 6 in. to 12 in.

● **B. C. Hall Constructors, Inc., P. O. Box 644, Aztec, New Mexico.** Has contract to build an undetermined amount of various sizes of pipelines ranging from 4-in. through 20-in. for *El Paso Natural Gas Company* in the Four Corners area of New Mexico.

● **Hallmac Construction Company, 3701 Buffalo Drive, Houston, Texas.** Has been awarded a contract by *United Gas Pipe Line Company* to install 43 miles of 30-in. pipeline from Mandeville, Louisiana, to Kiln, Mississippi.

● **Harbert Construction Corporation, P. O. Box 1369, Birmingham, Alabama.** Has nearly 500 miles of 18-in. and 20-in. main gas lines and more than 600 miles of 4-in. through 16-in. lateral lines under contract with *Houston Texas Gas and Oil Corporation* from Bradenton, Florida, to Miami, Florida.

● **Houston Contracting Company, 2807 Buffalo Speedway, Houston 6, Texas.** Has contract to lay approximately 117 miles of 30-in. natural gas pipeline for *Texas Gas Transmission Corporation* in central and north Louisiana, with initial headquarters at Pineville, Louisiana, and R. L. Silar as superintendent. Also awarded contract to construct 41 miles of 30-in. natural gas pipeline for *United Gas Pipe Line Company* in the vicinity of Gulfport, Mississippi, where the initial headquarters will be, and Mobile, Alabama. M. L. Thompson has been named superintendent.

● **International Marine Constructors, C. A., Caracas, Venezuela. (Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.)** Has been awarded a contract by the Iranian Oil Company to lay 25 miles of 30-in. at Ganaweh, on the Iranian shore, to Kharg Island, approximately 25 miles out in the Persian Gulf.

● **Macco Corporation, 14409 South Paramount Boulevard, Paramount, California.** Has prime contracts with various companies to construct pipelines in various sizes through 30-in. in California.

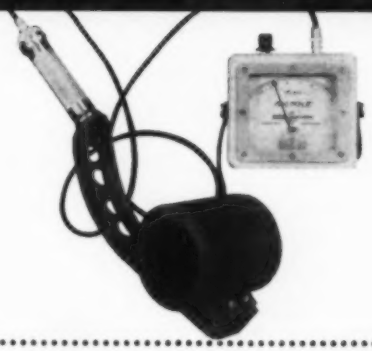
● **Majestic Contractors, Ltd., 408 Royal Trust Building, Edmonton, Alberta, Canada.** Has an undetermined amount of gas gathering system for *Producers Pipeline Company* in the Estevan, Saskatchewan, area.

● **J. Ray McDermott & Company, Inc., P. O. Box 38, Harvey, Louisiana.** Has been awarded a contract by *Venezuelan Sun* for an 18-in. crude pipeline from Block 1 in Lake Maracaibo to a terminal at Punta Palmas.

● **McVean and Barlow, Inc., P. O. Box 151, Odessa, Texas.** Has a contract to build 116 miles of 20-in. pipeline for *El Paso Natural Gas Company* in West Texas and Eastern New Mexico.

● **Midwestern-Waico Contractors, P. O. Box 11507, 1431 4th Street South, St. Petersburg 33, Florida.** Has been awarded a contract by *Houston Texas Gas & Oil Corporation* to lay approximately 700 miles of 24-in. main line between Baton Rouge, Louisiana, and Kissimmee, Florida, including a 24-in. crossing of the Choctawhatchee River at Caryville, Florida, and an 18-in. crossing of the Mobile River at Mt. Vernon, Alabama, and three compressor stations at Wiggins, Mississippi; Munson, Florida; and Quincy, Florida.

all IPEye's will be on U.E.*



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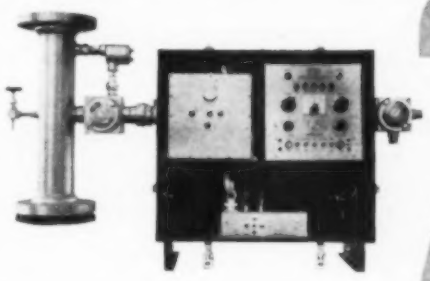

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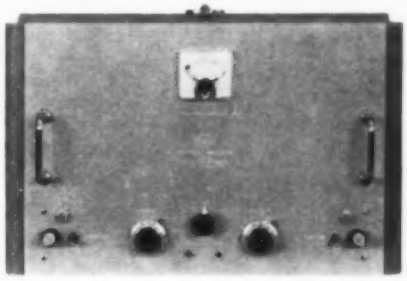

3 CUT POINT INDICATOR
This instrument is employed to accurately detect the arrival of the interface between two successive batches flowing in a common pipe line. The unit has been successfully employed on lines carrying fuel oil and standard petroleum products, as well as on lines carrying propane and butane. Circuits are provided for automatic control and switching.

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4 Accepts input variables such as pressure, temperature or current.

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Contractors

● **J. P. Neill & Company, Inc., 1200 Exchange Bank Building, Dallas 35, Texas.** Has been awarded 112 miles of 16-in. pipeline by *North Carolina Natural Gas Corporation* from Iredell County to a point northwest of Lumberton, North Carolina.

● **Oklahoma Contracting Company, P. O. Box 13227, Dallas 20, Texas.** Has contract for 130 miles of 24-in. between Lake Charles, Louisiana, and Baton Rouge, and 150 miles of 20-in. from Driscoll to Bay City, Texas, for *Coastal Transmission Corporation.*

● **Panama, Inc., 2201 Commerce Building, Houston 2, Texas.** Has been awarded a contract by *Humble Oil & Refining Company* to construct 238 miles of 30-in. natural gas pipeline from the King Ranch in Texas to the Clear Lake gas plant in Houston, Texas.

● **Panama-Williams Corporation, 1418 Melrose Bldg., Houston, Texas.** Has been awarded a contract by *Coastal Transmission Corporation* to construct 63 miles of 22-in. from West Columbia, Texas, to Galveston Bay; also a contract to lay approximately 125 miles of 24-in. pipeline in the vicinities of Centerville and Mt. Pleasant, Iowa, and Kewanee, Illinois, for *Michigan Wisconsin Pipeline Company.*

● **Rosson-Richards Processing Company, P. O. Box 908, Corpus Christi, Texas.** Has been awarded a contract by *Transcontinental Gas Pipe Line Corporation* to enamel and concrete coat approximately 32 miles of 16-in. pipeline. Headquarters location will be at the Delta Shipyards, New Orleans, Louisiana, under R. L. Miller, superintendent.

● **Sharman, Allen, Gay & Taylor, Inc., 3115 Buffalo Drive, Houston, Texas.** Has a contract to build 63 miles of 22-in. pipeline between Bay City and Galveston, Texas, for *Coastal Transmission Corporation.* Has been awarded contract also by *Freeport Sulphur Company* to lay approximately 33,000 ft of pipeline in south Louisiana. Field office for the latter job is Grand Isle, Louisiana, and spreadman is Chester Lake.

● **Sheehan Pipe Line Construction Company, 514 National Bank of Tulsa Building, Tulsa, Oklahoma.** Has been awarded a contract to construct for *Buckeye Pipe Line Company* 11 miles of 6-in. pipeline from Verona, New York, to Rome, New York.

● **Somerville Construction Company, 6648 Fulton Road, Ada, Michigan.** Has been awarded a contract by *Michigan Wisconsin Pipe Line Company* to construct 38.2 miles of 24-in. pipeline in Michigan. Harold Cook is superintendent and field office is located at Ada, Michigan.

● **Western Pipe Line, Inc., P. O. Box 1076, Austin, Texas.** Has been awarded a contract by *Texas Gas Transmission Corporation* to lay 8.72 miles and 10.03 miles of 26-in. loops in Kentucky, where field office will be located at Cloverport, under John R. Wells, spreadman; and to lay 9.49 miles and 9.23 miles of 30-in. loops in Mississippi, where field office will be located at Shaw under Aldress Kilgore, spreadman.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has received a contract from *Consumers Power Company* to construct 40 miles of 24-in. pipeline from Woodbury to Laingsburg Junction, Michigan. Also has been awarded a contract by *New York State Natural Gas Corporation* to take up 14½ miles of 14-in. and lay the same mileage of 26-in. in Tioga County, Pennsylvania. Spreadman for the latter job is Thelmer Davis.

Pipeline Projects

CONSTRUCTION

FEATURE

Big-Inch Crude Line Gets French Approval

Construction of a big-inch crude pipeline stretching almost 500 miles from the Mediterranean area to Strasbourg, France, and Karlsruhe, Germany, has received the French Government's approval, conditioned by construction of two refineries in each of the two areas which, heretofore, have had no such facilities.

Work on the $100,000,000, 28 to 32-in. pipeline is expected to begin by 1960, pending approval of the 19 participating companies and final governmental authorization.

Initial capacity of 200,000 bbl daily is expected to be increased to 400,000 bbl daily or more within 10 years as projected refinery needs increase.

Scheduled for construction also are two pumping stations with a 75,000,000 bbl capacity.

The companies participating include: British Petroleum Company, California Texas Oil Corporation, Petrofina, Royal Dutch Shell, Socony-Mobile, Esso Standard (New Jersey), and French and West German companies.

$6 Million Gas Facilities

Budget-type proposals by Michigan Wisconsin Pipe Line Company and Texas Gas Transmission Corporation, under which each would be permitted to expend $3,000,000 during a 12-month period for purchase laterals, have been approved by the Federal Power Commission. Michigan Wisconsin would be limited to $500,000 on any one project, and Texas Gas to $400,000.

U.S.-Financed Pemex Line

U. S. financing of a Pemex pipeline —a 214-mile products line between Monterrey and Torreon, Mexico . . . has been announced. The $6,500,000 financing arrangement was concluded between Tubos de Acero de Mexico, S.A., that will supply the 10¾-in. seamless steel pipe for the project, and Guaranty Trust Company of New York and the Continental Illinois National Bank and Trust Company of Chicago.

Michigan Wisconsin Starts Loop Project

Michigan Wisconsin Pipe Line Company announces that construction is underway on a project of 24-in. pipeline loops in Kansas, Missouri, Iowa, Illinois, and Michigan. (*Pipeline Engineer*, March 1959.) The construction will enable the company's system to transport a total of 80,000,000 cu ft of gas daily from the Laverne field.

Contractors announced for this construction are: R. H. Fulton & Company, 211.7 miles in Kansas, Nebraska, and Missouri; Panama-Williams Corporation, 124.3 miles in Iowa and Illinois; and Somerville Construction Company, 38.2 miles in Michigan.

Completion is scheduled for June.

Big Gas Line In Prospect for Texas

A major gas pipeline construction project is reported in the making for Texas.

Involved is an approximate 300-mile line from the Old Ocean field in Brazoria County on the Gulf Coast, northwest to the Fort Worth, Texas, area. Estimated cost is in excess of $20,000,000 for the 20 to 24-in. line which would move approximately 250,000,000 cu ft of gas per day.

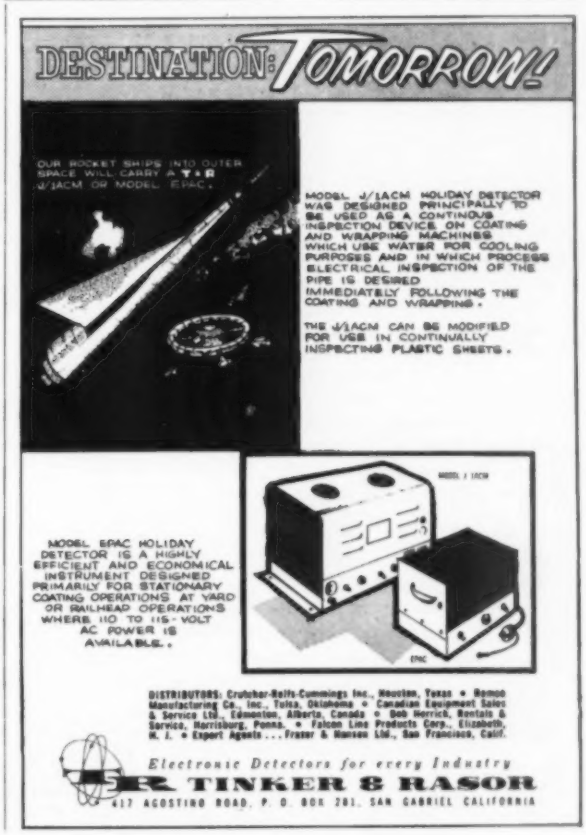
Announcement of the line project is expected shortly following completion of gas sales negotiations between Texas Electric Service Company, Fort Worth, and the gas sellers. Main gas sellers are Magnolia Petroleum Company, Dallas, and Pan American Petroleum Corporation, Tulsa. These firms own about 90 percent of Old Ocean's working interest.

Beeman Fisher, Texas Electric vice president, has confirmed that negotiations for the Old Ocean gas are in progress. If agreement is concluded, it is understood that Texas Electric would form a subsidiary to build the line and would have it in operation by December, 1960.

Okan Pipeline Plans Link to Mocane Field

Work is expected to start in June on a 28-mile, 4-in. pipeline that will transport natural gasoline and LPG products from the Warren -DX Mocane plant in Beaver County, Oklahoma, through Meade and Seward counties, Kansas, to Okan Pipeline Company's Liberal, Kansas, pump station. The Okan line is expected to be completed by the time the Mocane plant, being constructed by Warren Petroleum Corporation and DX Sunray Oil Company, is on stream. Okan is also building extra storage at its Liberal station to handle the larger volume of LPG through its trunk line.

Okan Pipeline Company is wholly-owned subsidiary of Warren, and operates a 350-mile products pipeline from western Kansas to Tulsa.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Projects

Transco Looping Project To Get May 18 Hearing

A May 18 hearing has been set by the Federal Power Commission on Transcontinental Gas Pipe Line Corporation's application to construct and operate facilities that would include 288.53 miles of pipeline looping, of which the major portion would be the installation of 36-in. partial third line loops primarily on its southern main line.

Included also in the proposed $68,966,000 project is installation of 61,380 hp in two new and 11 existing compressor stations located primarily on the northern part of its system, and additional field facilities to receive natural gas from several producers in Louisiana, as well as a loop on its lateral near Philadelphia.

The proposed facilities would provide 145,580,000 cu ft daily of additional pipeline capacity to meet increased requirements of existing resale customers and increase firm transportation service for Sun Oil Company by 9,000,000 cu ft per day.

Applications by seven natural gas producers seeking FPC authorization to sell gas to Transco from fields in Texas, Louisiana, and offshore Louisiana have been consolidated with Transco's application for this hearing.

Texas Eastern Starts Midwest Storage Tanks

Construction of more than a million barrels of tank storage capacity at Seymour, Indiana, to provide a vast midwestern reservoir for domestic burner oils to be delivered via the Little Big Inch from Texas and Louisiana Gulf Coast refining centers, has been started by Texas Eastern Transmission Corporation.

The first of four huge steel storage tanks will be completed in June, according to Millard K. Neptune, senior vice president in charge of Texas Eastern's Little Big Inch Division. The remainder of the tanks are scheduled to be in service early next fall in time for the winter fuel oil season. Two steel storage tanks will be of 325,000 bbl capacity each, one of 268,000 bbl capacity, and one of 87,000 bbl capacity.

South Texas Tie-In Begins

Pipelaying is beginning on South Texas Natural Gas Gathering Company's 115-mile line to link gas production in four South Texas counties with outlets to markets. It is part of a 290-mile system to tie reserves in Brooks, Starr, Hidalgo, and Jim Hogg counties to major transmission systems heading into midwestern and eastern markets.

O. R. Burden Construction Corporation was named contractor. The line is scheduled for completion by midspring.

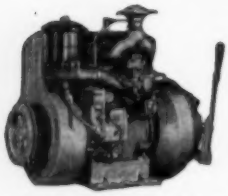
Columbia Gulf Adds 8.2 Miles In Louisiana

Columbia Gulf Transmission Company is now completing the last of three new projects totaling 8.2 miles of 6-in. line that will increase the company's gathering system in South Louisiana. They include: 1.6 miles into the Midwest-Ellis field, tying in to existing facilities on the North Maxey line; 5.8 miles into the Go Around Bayou field, tying into existing facilities at South Pecan Lake; and 0.8 of a mile from the suction side of the Rayne compressor station to a new well in the Midwest Branch field.

Syrian Line Discussed

Talks are in the early stages for a 500-mile pipeline from Karshuk field in Syria to the Mediterranean. United Arab Republic is carrying on the negotiations with the West German firm of Mannesmann.

WISCONSIN HEAVY-DUTY *Air-Cooled* ENGINES



Model THPD Oil Well Pumping Engine with heavy-duty clutch and extra flywheel for developing follow-through High Momentum Factor.

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Models ACN-BKN single cylinder 3- to 7-hp. (smallest engines in the Wisconsin line).

ROUGH-AND-READY oil field service calls for everything you can put into an engine — for on-the-job endurance, long life, self-sustaining dependability, low-cost operation and maintenance. You get it all in *all* Wisconsin Engines, regardless of type or hp. rating.

Even the smallest Wisconsin single-cylinder models have basic features such as: tapered roller main bearings . . . at *both* ends of the drop-forged, counterbalanced, heat-treated crankshaft; 4 piston rings for a tight power seal and protection against excessive cylinder wear; an outside-mounted, weather-tight high-tension rotary-type magneto, equipped with Impulse Coupling for fast starts in any weather; positive pump-circulated lubrication . . . and many other "plus value" features.

A complete power range from 3 to 56 hp. offers selectivity to fit the job and the machine. All models are designed for efficient operation at all temperatures from low sub-zero to 140° F., and can be supplied with Electric Starting, Automatic High Temp. Safety Switch. Buyer's choice of fuel systems: gasoline, natural gas, LPG or combination gas and gasoline.

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Tapered roller main bearings take up radial loads and end thrust . . . protect against bearing failure.

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Three Companies Seek West Texas Facilities

A hearing has been scheduled by the Federal Power Commission for May 4 on pipeline applications involving gathering facilities costing $9,589,500 in fields in West Texas.

Applicants are: Pioneer Gathering Systems, Inc., proposing construction of facilities to cost $3,687,100 to enable it to receive and transport 80,000,000 cu ft of gas daily from various Texas fields for delivery to Permian Basin Pipeline Company at a point in Schleicher County, Texas; Permian, applying to construct 83 miles of 16-in. line from its connection with Pioneer's proposed facilities to Permian's existing facilities at Spraberry, Texas, which, with a proposed 3960-hp compressor station, is estimated to cost $5,053,400; and El Paso Natural Gas Company, seeking authority to construct $849,000 gathering facilities to transport gas available to Pioneer in the Sonora and Buckhorn fields and available to El Paso in the Vinegarone field.

Pioneer said that if El Paso should be authorized to transport the gas, Pioneer would withdraw its application covering duplicate facilities costing about $86,500.

"Budget" Plans Filed

Natural Gas Pipeline Company of America and El Paso Natural Gas Company have filed two unrelated budget-type proposals with the Federal Power Commission.

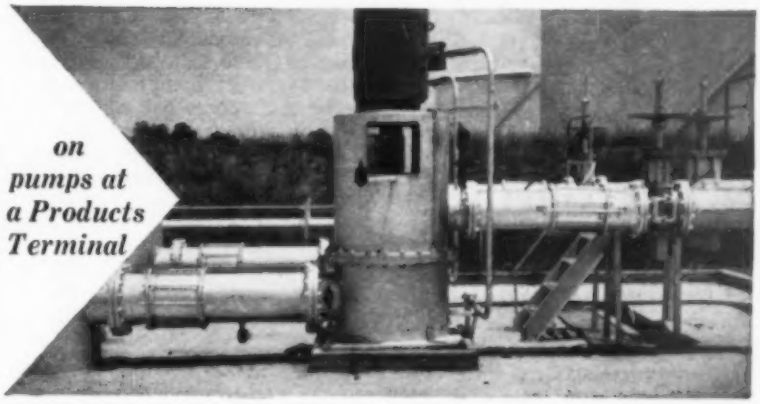
Natural's proposal includes 1959 construction of facilities, not to exceed $1,000,000, to enable it to receive natural gas from independent producers in areas adjacent to its existing system. The cost of facilities into any one producing area would not exceed $250,000.

El Paso's proposal includes construction during 1959 of not more than 30 main line taps at a cost of $8250; not more than 15 meter stations, with a maximum cost of $90,000; and two lateral or branch lines totaling $700,000.

U.S. Firm On Foreign Line

Construction of a 124-mile Netherlands-Germany pipeline has begun, and a Houston, Texas, firm has been named in combination with several foreign companies as contractors for the project. Foreign Construction Company of Houston, Texas, with D. Blankevoort & Zoon and F. Boersma, both of the Netherlands, and two firms from Cologne, Germany, are laying the line, which will take approximately a year to complete.

Dresser® Couplings—



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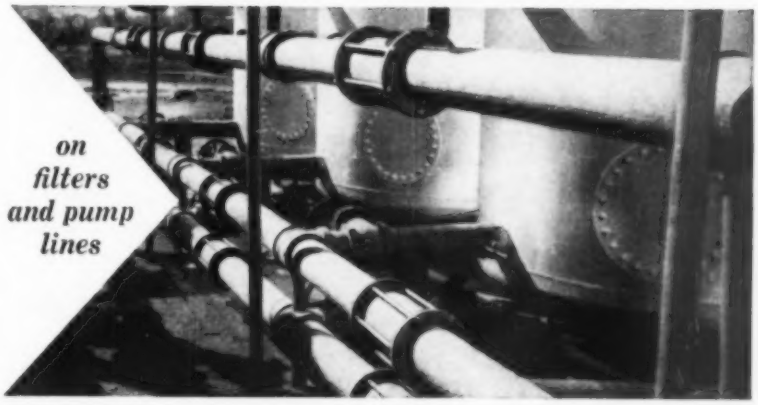

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D-87

Canadian News Notes

CONSTRUCTION

FEATURE

St. Lawrence Span In Quebec Firm's Plans

To capitalize on industrial activity along the booming south shore of the St. Lawrence river, Quebec Natural Gas Corporation will embark immediately on a $10,000,000 expansion program, it has been reported, some $5,000,000 of which will be spent to extend its pipeline across the St. Lawrence and along the shore between Laprairie and Contrecoeur, and the remaining $5,000,000 to be spent within three years for lateral lines and extended distribution systems.

The Quebec Natural Gas line will be the first to surmount the river barrier. The South Shore link will be hooked up with the company's 34-mile trans-island (Montreal) line — joined, in turn, with Trans-Canada Pipe Line's terminus at Senneville—and likely will be strung across the 2-mile Jacques Cartier Bridge. This method of crossing — suspending the pipeline from hangers—requires final approval. The alternate would be a submarine crossing, contending with swift current and a depth of 50 ft.

Saskatchewan Crossing First 1959 Canadian Completion

The first pipeline construction job to be finished in 1959 was completed early in March with the pulling of a 2800-ft, 10-in. crossing of the South Saskatchewan River, near Saskatchewan Landing Bridge, 30 miles north of Swift Current, for Saskatchewan Power Corporation's north-south gas line link between its north and south systems. The contract for the 76-mile line has not yet been let.

Engelking & James Ltd. of Edmonton was the contractor for the river crossing. The ditch was kicked off on February 21, and the entire job took only three weeks. A 1½-yd backhoe cut the ditch from the 2½-ft ice cover on the river, straddling a channel that was sawed through the ice. A ¾-yd backhoe cut the approaches.

The pipe was made up in three sections, with two tie-in welds at the water edge as the sections were pulled. Water in the river, at its seasonal low, was only 6 ft deep and 450 ft wide. A sand bar of 800 ft made up the rest of the river bed. Approaches were 700 and 850 ft on the south and north banks, respectively.

Only 1 ft of frost was found in the ground. Ditch held up excellently as most of it was in blue clay and hardpan.

Jack Engelking was general superintendent; F. Laurent (Frenchy) Brassard superintendent; Peter Boyko office manager; Joe Redman equipment superintendent.

Gas Interconnections

Saskatchewan Power Corporation is planning the immediate start of three pipeline construction projects that will total approximately 268 miles of transmission lines ranging from 6 to 10 in. The first, the Saint Louis to Tisdale transmission line, consists of approximately 52.5 miles of 6-in. and 24 miles of 4½-in. The second project consists of about 79 miles, 1600 ft of 10-in. from Success to Rosetown. The third project, Regina to Yorktown, consists of approximately 113 miles of 8-in.

Northwest Utilities Expansion Program

Northwestern Utilities, Ltd., has announced one of its largest expansion programs for 1959 with expenditure of $4,800,000 planned to extend its natural gas distribution system. It intends to add 5500 services.

Extensions, services and meters will cost $1,300,000. Service will be extended by new laterals to Provost and Cadogan in eastern Alberta, and to Thorsby, Breton, Warburg, Sunnybrook, and Buck Creek in west central Alberta from the Pembina main branch.

Quoted from Mr. Dillard Stokes' Column, Shreveport Journal, Oct 13, 1958..
"President Jefferson feared the justices some day would do what they now are accused of. A few months before he died President Jefferson wrote: 'There is no danger I apprehend so much as the consolidation of our government by the noiseless, and therefore unalarming, instrumentality of the Supreme Court'."
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WILKINSON Line Locator Model W-3

This radically new, powerful transistorized sub-surface locating instruments weighs only four pounds and is one-fourth the size of conventional pipe locators.

It's as handy as a flashlight; the transistors will rarely ever require replacing; non-leak mercury cells will last at least ten times longer. The maintenance is trivial. Molded glass fibre instrument cases insure maximum protection. The aluminum connecting handle telescopes to 17" and the entire instrument is packed in a substantial carrying case.

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Compressor Engines Sledded To Site Over Muskeg

Making a winter start on construction of its compressor stations in northern Ontario, Trans-Canada Pipe Lines, Ltd., recently completed an unusual hauling job to deliver the equipment for one station in muskeg terrain before the spring breakup. Three 100-ton engines had to be sledded 7 miles along a primitive side road and 10,000 ft along the right-of-way on muskeg ground, with an 8-ton specially fabricated sled measuring 32 ft long by 11 ft wide.

The engines are being installed later in the year at the Geraldton compressor station on the section of the pipeline owned by Northern Ontario Pipe Line Crown Corporation but designed and operated by Trans-Canada. They were delivered from the Canadian National Railways line at Geraldton, then had to be hauled through the main street of the little mining town and out to the site.

Each engine is 2500-hp,, and each one made an entire sled load. The sled was fabricated by Trans-Canada personnel in the company yard in Port Arthur and trucked the 100 miles to Geraldton. One sideboom tractor and a bulldozer pulled the load to the station site, with two more bulldozers pushing. Weather was satisfactory, with 4 ft of frost in the ground and a heavy snowstorm the night before the first move, so that traveling conditions were excellent. The sled was made of channel iron I-beams and H-beams, with ¼-in. steel plating on the entire underside to protect against rocks and stumps on the right-of-way. For pushing and pulling, 11-ft A-tongue drawbars were installed at both front and rear.

Interprovincial Makes Reduction in Tariff

A large tariff cut has been announced by Interprovincial Pipe Line Company, reflecting partly the increased volume of throughput to Toronto and more largely the threat to the competitive position of Canadian crude in Ontario by the imminent opening of the St. Lawrence deep seaway.

The company cut its tariffs by 8 cents per bbl from Edmonton and 5 cents from Cromer, Manitoba, to Sarnia, reducing them to 56 and 43 cents, respectively. The extended tariff from Sarnia to Toronto was cut in half, from 8 to 4 cents, making the inclusive rates 60 cents from Edmonton to Toronto and 47 cents from Cromer to Toronto.

Tariffs to intermediate American points are to be reduced also, but are delayed until the filing of tariffs with the Interstate Commerce Commission in Washington, said President T. S. Johnston. He added that during the first two months of 1959 the average deliveries to Toronto were over 90,000 bbl per day, more than double the 42,-366 bbl per day average in the same two months last year.

The company does not expect to have a similar increase throughout the year, Johnston said, but it does expect to deliver at least 50 percent more crude to Toronto. Deliveries to Sarnia are forecast for a smaller growth of about 10 percent over their 1958 average of 113,559 bbl per day for the entire year.

Alberta Gas Trunk Line Opens District Offices at Brooks

The Alberta Gas Trunk Line Company, Ltd., has established district headquarters for its southern territory at Brooks, and will set up a central district office at Drumheller. It has built 45 company houses for staff at seven towns in the southern sector and intends to build 12 to 15 this year in the central and western areas.

Warehouses are in operation at four points, and two more will be built this year in the northern part of the operating area. According to J. C. Mahaffy, general manager, if and when the large export line south is approved, Trunk Line will have to increase capital expenditure by $100,000,000.

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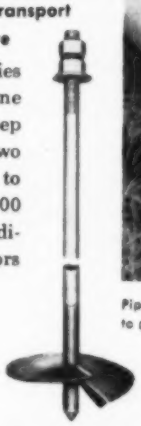
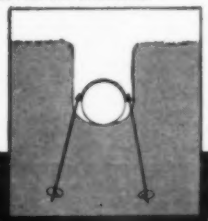
More and more progressive pipeline companies and contractors are turning to Chance Pipeline Anchors to eliminate costly counter weights to keep pipe from floating. A complete unit, consisting of two anchors and pipe saddle bracket, weighs from 29 to 180 pounds and will hold from 5,000 to 30,000 pounds. The anchors can be installed without additional excavation. Light power tools screw the anchors down in seconds.

Pipeline crew installing Chance Pipeline Anchors to prevent flotation problems in British Columbia.





Cut away view of anchors and bracket installed in trench.

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PIPELINE PERSONALS

▸ **D. S. Purnell,** manager of operations for Laurel Pipe Line Company, has been elected vice president in charge of operations. Purnell is a 25-year veteran in the pipeline industry and was associated with Sun Pipe Line Company and Sinclair Pipe Line Company before joining Laurel in 1957. Laurel Pipe Line Company announced that all other officers of the company were re-elected at the recent annual meeting. Directors are: **H. B. Brown, M. W. Ramsey,** and **W. L. Shannon** of Gulf Oil Corporation; **J. W. Emison** and **J. W. Green** of the Texas Pipe Line Company; **G. H. Giles, K. T. Feldman** and **E. B. Jordan** of Sinclair Pipe Line Company; and **W. J. Wilkins,** president, Laurel.

▸ **Fred M. Odom, Jr.,** a vice president of United Gas Corporation, United Gas Pipe Line Company, and Union Producing Company since 1957, has been elected a director of Union Producing Company.

▸ **James T. Butterfield** has been elected a director and **Louis M. Miller** an assistant secretary of Sun Pipe Line Company, and **Charles F. Heidrick** has retired from the board, according to an announcement by **William C. Kinsolving,** president. Butterfield is general superintendent of the crude line department, Beaumont, Texas. Miller is stationed at the company's headquarters in Philadelphia, Pennsylvania. Heidrick, retiring from the board, will devote full time as assistant general attorney, Gulf Coast division, Sun Oil Company.

▸ **George G. Hughes, Jr.,** formerly assistant to the general superintendent of Interstate Oil Pipe Line Company, has been named superintendent of the Vivian, Louisiana, district.

▸ **Harold W. Moles,** compressor-station superintendent for Pacific Northwest Pipeline Corporation, has been transferred to Pocatello, Idaho, as district pipeline superintendent.

▸ **Harrison C. Cambern** has been promoted to assistant district superintendent of Panhandle Eastern Pipe Line Company's Hugoton, Kansas, district, replacing **Wilbur D. (Pat) Dickey** who recently was transferred to Pittsfield and promoted to district superintendent there. In other appointments and moves announced by Panhandle, **Ivan E. Dettmer** has been added as a field safety engineer in Region 1 and will be stationed at Liberal, Kansas; **E. W. (Gene) Houchen,** assistant plant superintendent at Liberal, has moved to Louisburg, Kansas, to assist in the operation of the station during the temporary absence of **W. W. Osborn,** superintendent; and **Walter M. Struble** has been named new VHF technician at Tuscola, Illinois, replacing **David T. Bennett,** who is transferring to Liberal.

▸ **Robert F. McNamara,** engineer, has joined Ford, Bacon & Davis, Inc. McNamara was formerly with Arabian American Oil Company.

▸ **Samuel C. Phelps,** former chief engineer for Interstate Oil Pipe Line Company, has been appointed to the position of manager, operating services, in the company's general office in Shreveport, Louisiana. Phelps will have responsibility for the engineering department, material-traffic department and supervisor of tariffs, and will work under the directon of **W. F. Davis,** vice president and general manager.

▸ **Walter J. Herridge, Jr.,** has been transferred by Lone Star Gas Company from Temple, Texas, to the Shamrock, Texas, compressor station as superintendent, succeeding **Cecil Cardwell** who has retired.

▸ **Ralph Lynch** has been appointed general sales manager of Southern Mill Homes Company of Tulsa, Oklahoma, according to **A. R. Tandy,** president.

▸ **Winfield S. Schmidt** has been named assistant manager of the Crude Oil Pipe Line Division of the Atlantic Pipe Line Company, Dallas, and will become division manager upon the retirement of **J. Harry Wood, Jr.,** in July. Schmidt has been manager of the operations section of the company's Crude Oil division since 1958.

▸ **Raymond W. Miller** has been named manager of gas supply for Northern Natural Gas Company's recently opened office in Billings, Montana, which will investigate prospective natural gas sources in North Dakota, Montana, and Wyoming. Miller was formerly with the U. S. Bureau of Mines Helium Activity at Amarillo, Texas.

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The **new** Model "O", 7½ pounds of precision equipment, makes fast work of cutting and beveling 1½" to 4" pipe. One operator can easily handle this versatile unit, and completely perfect bevels are assured from the moment the torch is fired up . . . even with non-skilled operators.

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The Model "O" is just one of seven H&M machines designed to meet your pipe cutting and beveling needs on 1½" to 36" pipe. Write for illustrated catalog and specification sheets.

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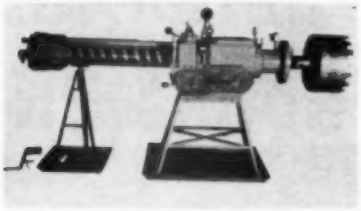
M. B. SKINNER COMPANY
SOUTH BEND 21, INDIANA, U. S. A.

It's New Pipeline Equipment

Powered Units Provide High-Pressure Hot Taps



Two new high-pressure machines for "hot tapping" oil, gas and products lines have been announced. The Mark I unit has either air motor or hand crank power, covers the range of high-pressure taps from 1 to 6 in. diameter, and uses twist drill cutters to 3 in. diameter or shell type cutters up to 6-in. The Mark II unit uses air or hydraulic power coupled with shell cutters to provide cuts from 4 to 16-in. diameter. *F. H. Maloney Company.*

Circle number (81) on reply card.

American Market Gets Anti-Corrosion Line

Denso anti-corrosive and waterproofing products, permanently pliable compounds based on the use of petroleum jelly — are being made available to the American market. The Denso process consists of the impregnation and coating of various fabrics, with a particular quality of petrolatum, mixed with inert substances to provide a covering that is of sufficient thickness to insure protection against chemical and electrolytical corrosion and to remain permanently pliable. The cold application type of Denso products are for a temperature range of — 50 F to + 200 F, while Denso Therm products contain special additives for high working temperature and require some heat for application . . . for temperatures encountered from — 60 F to + 280 F. Oxidizing oil in various colors, pastes, pliable compound, and saturated tapes form the line, as well as special products to meet unusual specifications. *Denso, Incorporated.*

Circle number (82) on reply card.

New Casing Insulator

A new casing insulator manufactured from high strength ⅛-in. steel has been introduced to protect carrier pipe from crossing casings and to facilitate pipe installation. Its special shape minimizes drag friction when threading carrier pipe through the casing; its one point steel contact to casing allows pipe to slide easily; and its broad bearing surface protects pipe coating, evenly distributes the load, reduces cold flow of the coating, and helps keep the insulator anchored on the carrier pipe to give proper final spacing on the pipe in the casing. In a range of sizes from 6-in. ID to 36-in. OD, with gaskets of a special grade of insulating rubber. *Dresser Manufacturing Division.*

Circle number (83) on reply card.

Improved Pipelayer

A new Caterpillar MD7 pipelayer with the following features has been announced: "Lifetime-lubricated" track rollers, carrier rollers, and idlers; a "floating ring" seal providing more end-play; addition of a turbocharger, increasing engine flywheel horsepower to 140; a dry-type air cleaner on the engine; gear teeth having coarser pitch; and 200-lb weight increase. *Caterpillar Tractor Company.*

Circle number (84) on reply card.

Anchor Assembly Designed For Permanent Hold-Downs

A positive expanding anchor and pipe saddle, designed specifically for protection to pipe coating and for permanent hold-downs of all kinds of pipeline construction have been announced. An expanding joint pad provides additional protection for pipe coating. The pipeline anchor assembly is made of certified malleable iron, and the pipe saddle is made of 10-gage galvanized sheet steel. *Grip-Tite Manufacturing Company.*

Circle number (85) on reply card.

For Drying Gases

An adsorbent for drying a wide variety of gases, liquids and vapors is this new type of active alumina in the form of spheres. It is shown here in 3 different diameters — ⅛-in., ¼-in., and ½-in. The active alumina is said to possess high sorptive capacity, mechanical strength and abrasion resistance, while the sphericity results in minimum pressure drop. *Kaiser Aluminum & Chemical Corporation.*

Circle number (86) on reply card.

Tank-Cleaning Tool

A specialized new tool for applying solvents used in chemically cleaning small storage tanks, horizontal, cylindrical tanks, and tank cars has been announced. The new tool jets solvents from 2 nozzels in a revolving jet head powered by a hydraulic motor. The jet head rotates through 360 deg both horizontally and vertically. Solvents reach the jet head through a line from a special truck-mounted pump outside the tank. Other lines carry the fluid that powers the hydraulic motor. The jet tool can be suspended inside the tank through a manhole at the top or placed on the tank floor. A plate seals the manhole, preventing chemical solvents from escaping, and allowing the tank to be flooded with inert gas, when desirable. *Dowell Division, The Dow Chemical Company.*

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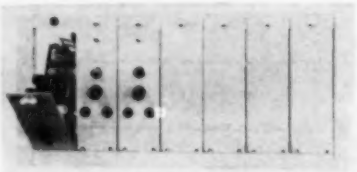
New Equipment

Audio Tone Equipment With "Flip-Out" Design



A new line of transistorized audio tone equipment (type KA) is offered which, on one pair of wires or any single voice frequency channel, will give up to 18 channels for telemetering, control, supervision, data transmission and other telegraphic-type functions. A new self-supporting "flip-out" package design provides accessibility from the front of the panel. Basic units — power, transmitter, and receiver panels — are mounted on a frame the size of a standard 19-in. wide relay panel, 5-panel units high. All panels are the same size, allowing any combination of transmitters and receivers totaling 6 panels and one power panel to be mounted in each frame. *Westinghouse Electric Corporation.*

Circle number (88) on reply card.

Light, Self-Propelled Pipe Cleaning Machine

A new lightweight Remco self-propelled pipe cleaning machine can clean up to 25 ft of pipe per min and requires but 6-in. of clearance under the pipe. It has been designed for new pipe as well as for maintenance and repair work on existing pipe, and is said to be applicable for working on loaded oil, gas or products lines. The cleaning head's floating design permits easy passage over collars, patches and bell and spigot pipe. It is available in five models each of which will clean 4 successive sizes of pipe from 2 through 24-in. *Remco Manufacturing Company.*

Circle number (89) on reply card.

Transistorized Voltmeter

An all-transistorized battery-operated a-c voltmeter has been introduced for use in designing, testing, installing, adjusting, and servicing electrical and electronic equipment of many types. The unit features: 7 transistors; full scale readings of 1 mv to 300 v in 12 ranges with an essentially flat frequency response of 20 cycles to 1.5 mc; and accuracy over the wide temperature range encountered in field use. The unit weighs approximately 5 lb, measures 5 in. by 5 in. by 10 in., and is housed in a steel case. *Motorola Communications & Electronics, Inc.*

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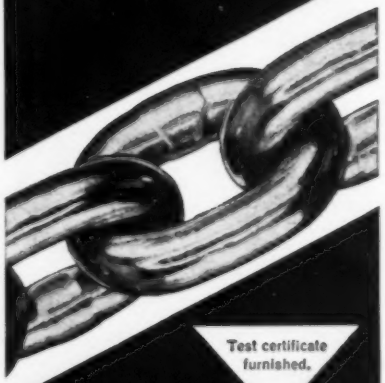

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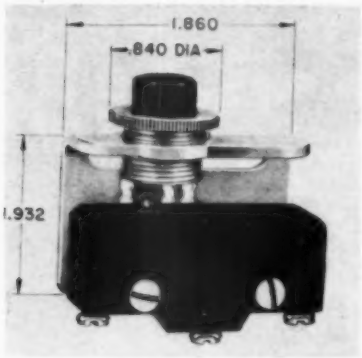
New Equipment

Pushbutton Actuators For Variety of Switches



A new series of pushbutton actuators has been introduced for use with a wide variety of basic switches, allowing a designer to achieve uniform panel-front appearance while using all types of basic switches for varied electrical requirements. Buttons are ½-in. and 1-in., in anodized aluminum bushings, and both sizes fit panels from .060-in. to .312-in. thick. Actuators fit all pin-plunger basic switches, "1TB" and "41TB" switches made by Micro Switch. Switch mounting holes — adjustable in three steps — allow the user to position basic switches on the actuators for best button travel. *Micro Switch, Division of Minneapolis-Honeywell Regulator Company.*

Circle number (91) on reply card.

New Turbocharged Model Packaged Field Compressor

A new turbocharged packaged field compressor has been announced, with 20 percent increase in hp output over similar non-turbocharged units in the line. With 4 compressor cylinders, the Model TMB-8 is rated at 525 bhp. Although hp output is increased, loading on the power end of the machine is not increased because the scavenging load is removed when the compressor reaches rated load conditions. Power formerly used for scavenging is now used to pump gas. Designed for field service — including pipeline testing and pressure maintenance — it is said to be well suited for areas with unstable soil conditions because of its vibration-free performance. *Clark Bros. Company.*

Circle number (92) on reply card.

Coupling For Confined Operational Space

A new coupling has been developed to meet the demand for joining pipe and tubing especially where operational space is confined or where remote control operation is required. Known as the Geartight Union, the coupling consists primarily of a conventional coupling to which a gear and pinion locking mechanism has been added. The pinion is removable from the coupling. It may be operated either by a ratchet spanner, a gear key or other remote control means. By turning the key or ratchet of the pinion, the gear nut rotates and the joint is tightened. *Stanat Manufacturing Company, Inc.*

Circle number (93) on reply card.

NEW PIPELINE LITERATURE

U. S. Rust Index, Corrosion Map

A rust index of the United States, accompanied by a corrosion map, giving years and months required to corrode uncoated steel test panels in given areas and cities, has been published by The Rust-Oleum Corporation. A product booklet also covers various type coatings and their applications. *The Rust-Oleum Corporation*

Circle number (94) on reply card.

New In Automation

The Automatic Keysort System for data processing, in which original records are used to achieve automation without transfer of data to other unit cards or tape, is featured in Royal McBee Corporation's new brochure, "New Concepts in Practical Automation and Electronic Computers." Also illustrated, with a presentation of its characteristics and capacities, is the LGP-30 electronic computer. *Royal McBee Corporation.*

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Unique "Containerized" Materials Handling

The Dempster-Dinosaur for materials handling . . . employing any necessary number of detachable containers up to 40 cu yd capacity and over . .. is described in a new booklet. The Dinosaur backs up to the container with its tipping frame at a 45 deg angle and pulls it into carrying position with a bail . . . moved forward and backward with a double-acting cylinder . . . which engages a series of lifting hooks on the container's underside guide rail. The ratcheting cycle is reversed, with the bail pushing against the back of the hooks, to put the container down . . . or its contents may be dumped. Only one man, the driver, is required for the completely hydraulic operation. *Dempster Brothers.*

Circle number (96) on reply card.

Condulets for Use In Corrosive Locations

Corrosion-resistant properties of a variety of metals and finishes used in Crouse-Hinds condulets are described in "Condulets for Corrosive Locations," a new 16-page bulletin. Simple charts show the applications of each, and the booklet is highlighted by the first formal listings of Plast-A-Coat condulets for hazardous and non-hazardous locations. *Crouse-Hinds Company.*

Circle number (97) on reply card.

Diesel Crawler Data

New specification sheets have been issued on Allis-Chalmers' HD-16 and HD-16 DC and D diesel powered crawler tractors, giving cutaway views and marginal notes. *Allis-Chalmers Manufacturing Company.*

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New Literature

Pipeline Strainers

A new bulletin illustrates and discusses, with sectional assembly drawings and complete dimensional, capacity, and sizing data, a line of newly-designed, single-basket pipeline strainers. They are in 2, 2½, 3, 4 and 6-in. sizes, all with flanged connections. Rating is 125 psig working pressure (cold). Standard basket construction is stainless steel plate with ⅛-in. perforations. The ratio of basket free area to cross-sectional flow area of the strainer connections is 5 to 1. Sealing of the basket to the strainer body is accomplished with compressive force applied by the body cover through the basket handle. *Schutte and Koerting Company.*

Circle number (99) on reply card.

Telemetering Equipment

A 36-page comprehensive catalog of multichannel telemetering equipment is available. Designated Catalog 900, it gives clear-cut illustrations, descriptions and specifications of representative multichannel equipment for telemetry and for other instrumentation applications. *General Devices, Inc.*

Circle number (100) on reply card.

For Control Panels

"Series 2 Lighted Display and Pushbutton Switch Devices" shows in its 20 full-color pages this new system of devices in combined indication and control. Features described are: Parts which snap together to form combination switch-indicator devices; a selection of indicator color combinations and mounting schemes for the panel front; easily-connected terminals behind the panel; and a selection of switch units to clip to the operator units to meet almost any switching requirement. Series 2 devices are designed to meet performance needs of electronic data-processing systems, computers, graphic flow panels, supervisory test panels, etc. *Micro Switch, Division of Minneapolis-Honeywell Regulator Company.*

Circle number (101) on reply card.

New Welding Fittings

A new welding fittings catalog, covering an expanded line of seamless carbon steel welding fittings, is now available. Complete tables of specifications, product photos, engineering drawings, ASA tables, manufacturing details and information on related products are contained in the 2-color, 20-pager. *Dresser Manufacturing Division.*

Circle number (102) on reply card.

Crane-Excavator Data

An 8-page specification bulletin covers the new series 350 Bantam crane-excavators — giving complete specifications, capacities, work ranges and features of the 11-ton carrier-mounted model T-350, the 11-ton self-propelled model CR-350, and the model C-350 crawler-mounted Bantam, as well as the complete line of attachments. *Schield Bantam Company.*

Circle number (103) on reply card.

In-Line Submersible Pumps

A new illustrated bulletin, "Layne In-Line Submersible Pumps," describes Layne horizontal in-line submersible pumps for booster service, applications and uses. *Layne & Bowler, Inc.*

Circle number (104) on reply card.

Check Valve Bulletin

Piston controlled check valves are described in a revision of Daniel Orifice Fitting Company's catalog section "H." The new edition describes the patented, positive control features, and includes specifications and parts lists for 300 to 2500 lb. ASA, pipeline and general use valves. *Daniel Orifice Fitting Company.*

Circle number (105) on reply card.

Power Plant Controls

Application of newly-developed automatic controls for sensing power loads, starting, regulating, and shutting down engine-generating units to meet varying line demands is featured in a new 12-page engineering bulletin. *The Cooper-Bessemer Corporation.*

Circle number (106) on reply card.

Synchronous Motors

High-speed synchronous motors—their design features, construction and applications — are described in a new 4-page bulletin, with illustrations showing manufacturing techniques and typical installations. *General Electric Company.*

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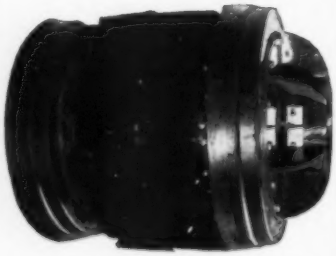

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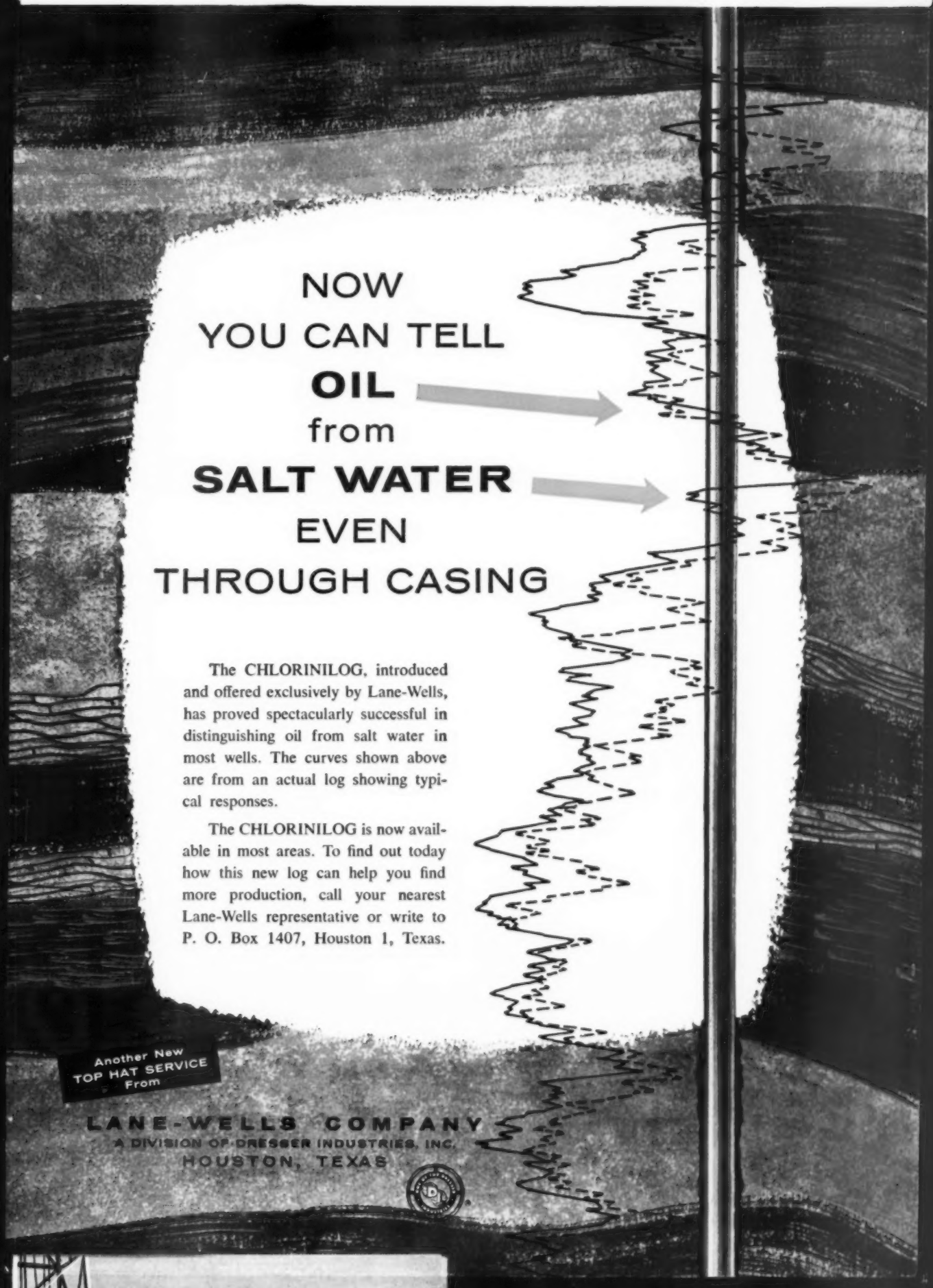
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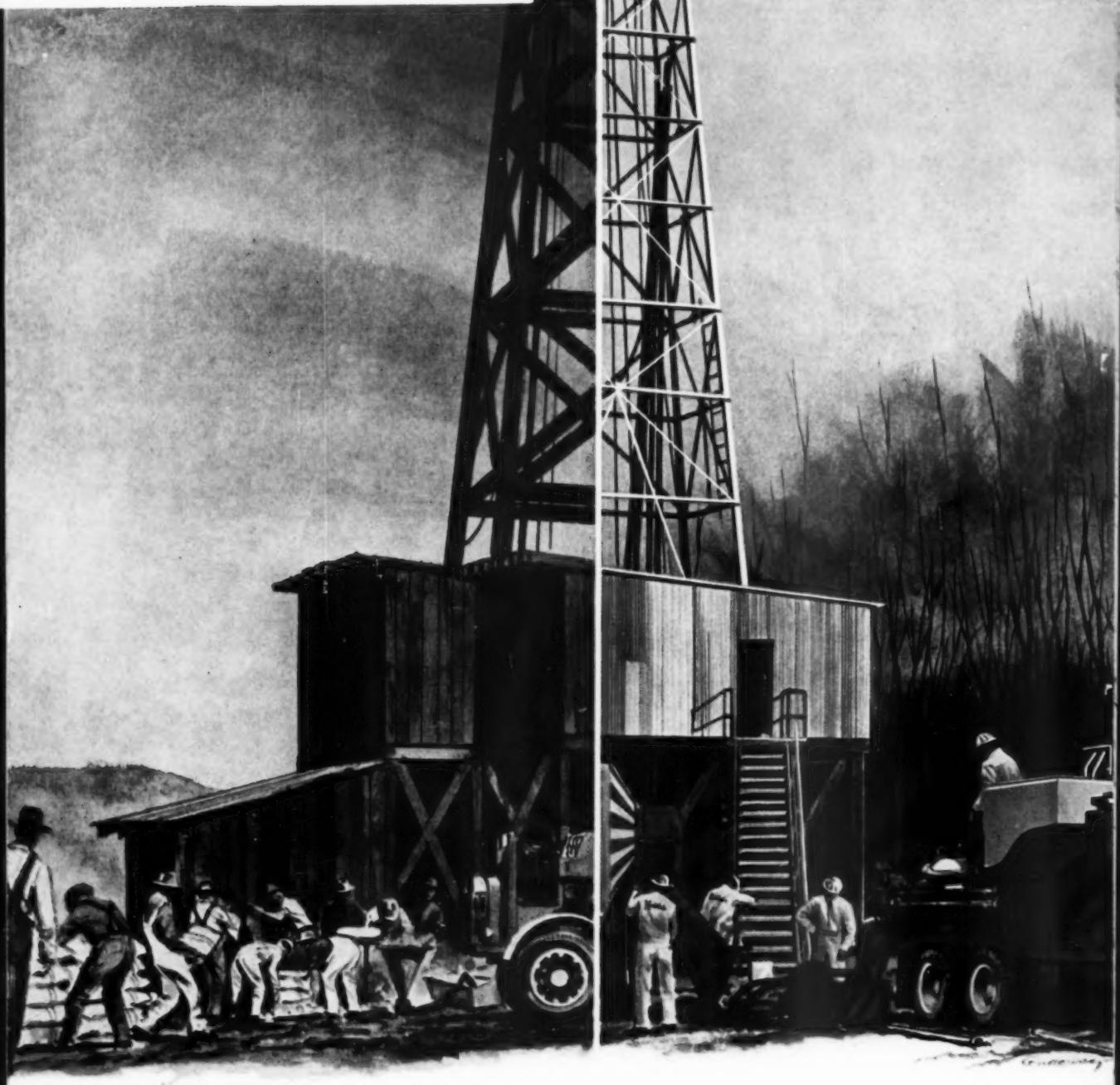

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